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Source Testing of a Stationary Coke-Side Enclosure. Great Lakes Carbon Corporation St. Louis, Missouri Plant. Volume II

Clayton Environmental Consultants, Inc, Southfield, Mich

Prepared for

Environmental Protection Agency, Washington, D C Div of Stationary Source Enforcement

31 Aug 77

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August 1977

PB 273 498

Stationary Source Enforcement Series

SOURCE TESTING OF A STATIONARY COKE-SIDE ENCLOSURE

GREAT LAKES CARBON CORPORATION
ST. LOUIS, MISSOURI PLANT

VOLUME II

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement
Office of General Enforcement
Washington, D.C. 20460

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16. ABSTRACT

This report summarizes a study of coke-side emissions at three coke-oven batteries producing foundry coke at Great Lakes Carbon Corporation (GLC) in St. Louis, Missouri. Of the three bateries, the south battery "A" is equipped with the coke-side shed. The center battery "B" and the north battery "C" were not equipped with a functional shed at the time of the study. Objectives of this study were to develop:

1) Basic engineering data concerning process eimssions, fugitive emissions from the shed, capture efficiency of the shed, and quantity and characteristics of contaminants present in the shed exhaust.

2) Other basic engineering data for specification of future retrofitted control devices for removal of air contaminants in the shed exhaust.

3) Correlations to relate these measurements to process conditions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Coking Air pollution Opacity Visual inspection Particles Particle size distribution	New Source Performance Standards Emission Testing Performance Tests	13B 14D

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STUDY OF COKE-SIDE COKE-OVEN EMISSIONS

(Volume 2 of 3 — Appendices A to I)

Great Lakes Carbon Corporation
St. Louis, Missouri

Contract No. 68-02-4108
Task No. 14

Prepared for:

Technical Support Branch
Division of Stationary Source Enforcement
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared by:

Clayton Environmental Consultants, Inc.
25711 Southfield Road
Southfield, Michigan 48075

August 31, 1977

DISCLAIMER

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APPENDIX A

EMISSION MEASUREMENT PROJECT PARTICIPANTS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Clayton Environmental Consultants, Inc.

John Mutchler, P.E.	Contract Project Manager
Fred Cooper	Project Leader
Victor Hanson	Non-pushing-cycle particulate measurement, Assistant Project Leader
Gerald Schlaf, P.E.	Non-pushing particulate measurement
Richard Marcus	Pushing-cycle particulate measurement
George Santorilla	Pushing-cycle emission measurement
Richard Keller	Particle size measurement
John Knowles	Particle size measurement Gaseous contaminant measurement
James McClain	Gaseous contaminant measurement Gaseous contaminant analysis
Wilbert Lee	Dustfall measurement
Mark Wysin	Particulate, chloride, sulfur oxide analysis
Sally Akehurst	Particle sizing analysis
Kent Shoemaker	Nitrogen oxide and particle sizing analysis
Lawrence Beaubien	Gaseous contaminant analysis
Duane Root	Gaseous contaminant analysis
David Holmberg	Dustfall analysis
Michael Kelly	PNA analysis
Rebecca Cooper	Data processing
Janet Vecchio	Data processing
Kathy Hoskins	Clerical
Janice Nordin	Clerical

APPENDIX A (continued)

EMISSION MEASUREMENT PROJECT PARTICIPANTS

U.S. Environmental Protection Agency

Kirk Foster	Project Coordinator
Bernard Bloom	Technical Consultant
Louis Paley	Technical Consultant Source Testing Observer
Byron Taylor	Region VII Representative Visible Emissions Observer
Dr. Wayne Smith	Push Observer Visible Emissions Observer
Paul DePercin	Visible Emissions Observer
Norman White	Transmissometer Operation
Bruce McElhoe	Transmissometer Operation Visible Emissions Observer
Ron Mitchell	Photographer
Stan Coerr	Photographer

St. Louis Air Pollution Control Department of Public Safety

Tom Wiese	Visible Emissions Observer
Tom Frank	Visible Emissions Observer

APPENDIX B

PUSHING-CYCLE PARTICULATE TEST RESULTS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

FILTERABLE PARTICULATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3	4
Date		4/21-22	4/22	4/23	4/24
Sampling Period	Start	10:35 09:49	14:10	08:45	10:43
	Stop	17:55 12:02	18:48	14:59	13:44
Sampled Volume	Am^3 (1)	6.83	4.39	4.54	2.93
	DNm^3 (2)	6.70	4.22	4.37	2.73
	ACF (3)	241.3	155.0	160.2	103.3
	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		285.02	129.55	149.21	174.58
Particulate Concentration	mg/Am^3	41.7	29.5	32.9	59.7
	mg/DNm^3	42.6	30.7	34.1	64.0
	gr/ACF	0.018	0.013	0.014	0.026
	gr/DSCF	0.019	0.013	0.015	0.028
Particulate Emission Rate	kg/hr	9.3	6.2	7.1	13.2
	kg/M ton of feed	0.24	0.15	0.19	0.44
	lb/hr	20.6	13.7	15.7	29.0
	lb/ton of feed	0.48	0.29	0.38	0.88

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL PARTICULATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

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	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		300.42	153.45	181.01	193.68
Particulate Concentration	mg/Am^3	44.0	35.0	39.9	66.2
	mg/DNm^3	44.9	36.3	41.4	71.0
	gr/ACF	0.019	0.015	0.017	0.029
	gr/DSCF	0.020	0.016	0.018	0.031
Particulate Emission Rate	kg/hr	9.8	7.3	8.7	14.6
	kg/M ton of feed	0.25	0.17	0.23	0.49
	lb/hr	21.7	16.2	19.1	32.2
	lb/ton of feed	0.51	0.34	0.46	0.98

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE CYANIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle)   Dimensions: 89-3/4"x84"

Test Number		1		2	3	4
Date		4/21-22		4/22	4/23	4/24
Sampling Period	Start	10:35	09:49	14:10	08:45	10:43
	Stop	17:55	12:02	18:48	14:59	13:44
Sampled Volume	Am^3 (1)	6.83		4.39	4.54	2.93
	DNm^3 (2)	6.70		4.22	4.37	2.73
	ACF (3)	241.3		155.0	160.2	103.3
	DSCF (4)	236.5		149.1	154.3	96.3
Percent Moisture by Volume		0.99		0.75	1.3	2.0
Average Stack Temperature	°C	24		29	23	31
	°F	75		85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740		3500	3610	3660
	DNm^3/min (6)	3670		3360	3480	3410
	ACFM (7)	132,000		123,000	128,000	129,000
	DSCFM (8)	129,000		119,000	123,000	121,000
Percent Isokinetic.		99.9		102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8		42.7	37.9	29.8
	tons/hr	42.8		47.1	41.7	32.9
Sample Weight (mg)		<12.1		<6.84	<6.50	<6.03
Particulate Concentration	mg/Am^3	<1.8		<1.6	<1.4	<2.1
	mg/DNm^3	<1.8		<1.6	<1.5	<2.2
	gr/ACF	<0.0008		<0.0007	<0.0006	<0.0009
	gr/DSCF	<0.0008		<0.0007	<0.0006	<0.001
Particulate Emission Rate	kg/hr	<0.40		<0.33	<0.31	<0.45
	kg/M ton of feed	<0.01		<0.008	<0.008	<0.02
	lb/hr	<0.87		<0.72	<0.69	<1.0
	lb/ton of feed	<0.02		<0.02	<0.02	<0.03

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL CYANIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3	4
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Sampled Volume	Am^3 (1)	6.83	4.39	4.54	2.93
	DNm^3 (2)	6.70	4.22	4.37	2.73
	ACF (3)	241.3	155.0	160.2	103.3
	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		<28.7	<15.5	<18.8	<17.8
Particulate Concentration	mg/Am^3	<4.2	<3.5	<4.1	<6.1
	mg/DNm^3	<4.3	<3.7	<4.3	<6.5
	gr/ACF	<0.002	<0.002	<0.002	<0.003
	gr/DSCF	<0.002	<0.002	<0.002	<0.003
Particulate Emission Rate	kg/hr	<0.94	<0.74	<0.90	<1.3
	kg/M ton of feed	<0.02	<0.02	<0.02	<0.04
	lb/hr	<2.1	<1.6	<2.0	<3.0
	lb/ton of feed	<0.05	<0.03	<0.05	<0.09

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE CHLORIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) **Dimensions:** 89-3/4"x84"

Test Number		1	2	3	4
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	DNm^3 (2)	6.70	4.22	4.37	2.73
	ACF (3)	241.3	155.0	160.2	103.3
	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		0.548	0.938	1.170	1.240
Particulate Concentration	mg/Am^3	0.08	0.21	0.26	0.42
	mg/DNm^3	0.08	0.22	0.27	0.45
	gr/ACF	0.00004	0.00009	0.0001	0.0002
	gr/DSCF	0.00004	0.0001	0.0001	0.0002
Particulate Emission Rate	kg/hr	0.02	0.04	0.06	0.09
	kg/M ton of feed	0.0005	0.0009	0.002	0.003
	lb/hr	0.04	0.10	0.12	0.21
	lb/ton of feed	0.0009	0.002	0.003	0.006

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
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(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL CHLORIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) **Dimensions:** 89-3/4"x84"

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	ACF (3)	241.3	155.0	160.2	103.3
	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		6.818	6.798	7.020	5.670
Particulate Concentration	mg/Am^3	1.0	1.5	1.5	1.9
	mg/DNm^3	1.0	1.6	1.6	2.1
	gr/ACF	0.0004	0.0007	0.0007	0.0008
	gr/DSCF	0.0004	0.0007	0.0007	0.0009
Particulate Emission Rate	kg/hr	0.22	0.33	0.34	0.43
	kg/M ton of feed	0.006	0.008	0.009	0.01
	lb/hr	0.49	0.72	0.74	0.94
	lb/ton of feed	0.01	0.02	0.02	0.03

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(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE SULFATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3	4
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	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		3.4	0.7	1.6	0.9
Particulate Concentration	mg/Am^3	0.50	0.16	0.35	0.31
	mg/DNm^3	0.51	0.17	0.37	0.33
	gr/ACF	0.0002	0.00007	0.0002	0.0001
	gr/DSCF	0.0002	0.00007	0.0002	0.0001
Particulate Emission Rate	kg/hr	0.11	0.03	0.08	0.07
	kg/M ton of feed	0.003	0.0007	0.002	0.002
	lb/hr	0.25	0.07	0.17	0.15
	lb/ton of feed	0.006	0.001	0.004	0.005

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
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(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
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TOTAL SULFATE EMISSIONS SUMMARY

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St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle)   Dimensions: 89-3/4"x84"

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Date		4/21-22	4/22	4/23	4/24
Sampling Period	Start	10:35 09:49	14:10	08:45	10:43
	Stop	17:55 12:02	18:48	14:59	13:44
Sampled Volume	Am^3 (1)	6.83	4.39	4.54	2.93
	DNm^3 (2)	6.70	4.22	4.37	2.73
	ACF (3)	241.3	155.0	160.2	103.3
	DSCF (4)	236.5	149.1	154.3	96.3
Percent Moisture by Volume		0.99	0.75	1.3	2.0
Average Stack Temperature	°C	24	29	23	31
	°F	75	85	74	88
Stack Gas Flowrate	Am^3/min (5)	3740	3500	3610	3660
	DNm^3/min (6)	3670	3360	3480	3410
	ACFM (7)	132,000	123,000	128,000	129,000
	DSCFM (8)	129,000	119,000	123,000	121,000
Percent Isokinetic		99.9	102.9	100.4	100.6
Feed Rate	M tons/hr (9)	38.8	42.7	37.9	29.8
	tons/hr	42.8	47.1	41.7	32.9
Sample Weight (mg)		19.4	4.2	7.7	5.6
Particulate Concentration	mg/Am^3	2.8	0.96	1.7	1.9
	mg/DNm^3	2.9	0.99	1.8	2.1
	gr/ACF	0.001	0.0004	0.0007	0.0008
	gr/DSCF	0.001	0.0004	0.0008	0.0009
Particulate Emission Rate	kg/hr	0.63	0.20	0.37	0.42
	kg/M ton of feed	0.02	0.005	0.01	0.01
	lb/hr	1.4	0.44	0.81	0.93
	lb/ton of feed	0.03	0.009	0.02	0.03

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

APPENDIX C

NON-PUSHING CYCLE PARTICULATE TEST RESULTS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

FILTERABLE PARTICULATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		55.73	93.96	37.14
Particulate Concentration	mg/Am^3	14.2	20.5	7.6
	mg/DNm^3	14.3	21.3	7.9
	gr/ACF	0.006	0.009	0.003
	gr/DSCF	0.006	0.009	0.003
Particulate Emission Rate	kg/hr	3.1	4.5	1.8
	kg/M ton of feed	0.18	0.26	0.10
	lb/hr	6.9	10.0	3.9
	lb/ton of feed	0.36	0.52	0.20

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL PARTICULATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		58.73	104.56	50.34
Particulate Concentration	mg/Am^3	15.0	22.8	10.4
	mg/DNm^3	15.1	23.7	10.7
	gr/ACF	0.007	0.010	0.005
	gr/DSCF	0.007	0.010	0.005
Particulate Emission Rate	kg/hr	3.3	5.0	2.4
	kg/M ton of feed	0.19	0.29	0.13
	lb/hr	7.2	11.1	5.3
	lb/ton of feed	0.38	0.58	0.26

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE CYANIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle)   Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17.59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		<10.4	<8.97	<7.18
Particulate Concentration	mg/Am^3	<2.7	<2.0	<1.5
	mg/DNm^3	<2.7	<2.0	<1.5
	gr/ACF	<0.001	<0.0009	<0.0006
	gr/DSCF	<0.001	<0.0009	<0.0007
Particulate Emission Rate	kg/hr	<0.58	<0.43	<0.34
	kg/M ton of feed	<0.03	<0.02	<0.02
	lb/hr	<1.3	<0.95	<0.76
	lb/ton of feed	<0.07	<0.05	<0.04

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL CYANIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		<18.6	<17.1	<16.2
Particulate Concentration	mg/Am^3	<4.7	<3.7	<3.3
	mg/DNm^3	<4.8	<3.9	<3.5
	gr/ACF	<0.002	<0.002	<0.001
	gr/DSCF	<0.002	<0.002	<0.002
Particulate Emission Rate	kg/hr	<1.0	<0.82	<0.77
	kg/M ton of feed	<0.06	<0.05	<0.04
	lb/hr	<2.3	<1.8	<1.7
	lb/ton of feed	<0.12	<0.09	<0.08

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE CHLORIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle)

Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		0.878	1.800	0.678
Particulate Concentration	mg/Am^3	0.22	0.39	0.14
	mg/DNm^3	0.23	0.41	0.14
	gr/ACF	0.0001	0.0002	0.00006
	gr/DSCF	0.0001	0.0002	0.00006
Particulate Emission Rate	kg/hr	0.05	0.09	0.03
	kg/M ton of feed	0.003	0.005	0.002
	lb/hr	0.11	0.19	0.07
	lb/ton of feed	0.006	0.01	0.004

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL CHLORIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		3.588	4.050	4.088
Particulate Concentration	mg/Am^3	0.92	0.88	0.84
	mg/DNm^3	0.92	0.92	0.87
	gr/ACF	0.0004	0.0004	0.0004
	gr/DSCF	0.0004	0.0004	0.0004
Particulate Emission Rate	kg/hr	0.20	0.20	0.20
	kg/M ton of feed	0.01	0.01	0.01
	lb/hr	0.44	0.43	0.43
	lb/ton of feed	0.02	0.02	0.02

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

FILTERABLE SULFATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am3 (1)	3.92	4.59	4.86
	DNm3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am3/min (5)	3650	3690	3880
	DNm3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		<0.5	1.4	<0.3
Particulate Concentration	mg/Am3	<0.13	0.30	<0.06
	mg/DNm3	<0.13	0.32	<0.06
	gr/ACF	<0.00006	0.0001	<0.00003
	gr/DSCF	<0.00006	0.0001	<0.00003
Particulate Emission Rate	kg/hr	<0.03	0.07	<0.01
	kg/M ton of feed	<0.002	0.004	<0.0005
	lb/hr	<0.06	0.15	<0.03
	lb/ton of feed	<0.003	0.008	<0.002

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TOTAL SULFATE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Non-pushing cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	13:28	09:29	11:00
	Stop	18:18	17:59	16:31
Sampled Volume	Am^3 (1)	3.92	4.59	4.86
	DNm^3 (2)	3.89	4.41	4.69
	ACF (3)	138.3	162.1	171.6
	DSCF (4)	137.3	155.6	165.6
Percent Moisture by Volume		0.75	1.1	1.9
Average Stack Temperature	°C	21	29	21
	°F	69	85	70
Stack Gas Flowrate	Am^3/min (5)	3650	3690	3880
	DNm^3/min (6)	3630	3540	3740
	ACFM (7)	129,000	130,000	137,000
	DSCFM (8)	128,000	125,000	132,000
Percent Isokinetic		99.7	101.2	102.0
Feed Rate	M tons/hr (9)	17.3	17.5	18.2
	tons/hr	19.1	19.3	20.0
Sample Weight (mg)		1.0	5.3	<0.7
Particulate Concentration	mg/Am^3	0.26	1.2	<0.14
	mg/DNm^3	0.26	1.2	<0.15
	gr/ACF	0.0001	0.0005	<0.00006
	gr/DSCF	0.0001	0.0005	<0.00007
Particulate Emission Rate	kg/hr	0.06	0.26	<0.03
	kg/M ton of feed	0.003	0.01	<0.002
	lb/hr	0.12	0.56	<0.07
	lb/ton of feed	0.006	0.03	<0.004

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 1

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Cyclone Wash	>6.3	5.4	71.0	100.0	2.0	37.0
Stage 1	6.3-3.0	0.3	4.0	29.0		
Stage 2	3.0-1.8	0.2	2.6	25.0		
Stage 3	1.8-1.2	0.3	4.0	22.4	*	*
Stage 4	1.2-0.63	0.4	5.3	18.4		
Stage 5	0.63-0.40	0.8	10.5	13.1		
Final Filter	<0.40	0.2	2.6	2.6		

* The low total particulate weight combined with the large number of individual fractions, precluded a successful analysis for organic solubles.

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 2

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Stage 0	>6.8	9.2	67.2	100.0	1.2	13.0
Stage 1	6.8- 3.1	0.5	3.6	32.8	1.7	37.8
Stage 2	3.1- 1.8	1.3	9.5	29.2		
Stage 3	1.8- 1.3	0.6	4.4	19.7		
Stage 4	1.3- 0.66	1.2	8.8	15.3		
Stage 5	0.66- 0.42	0.7	5.1	6.5		
Final Filter	<0.42	0.2	1.4	1.4		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink
Test Number 3

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Cyclone wash	>6.8	6.9	69.0	100.0	0.4	5.8
Stage 1	6.8- 3.1	0.7	7.0	31.0	1.0	32.3
Stage 2	3.1- 1.8	0.4	4.0	24.0		
Stage 3	1.8- 1.3	0.3	3.0	20.0		
Stage 4	1.3- 0.66	0.6	6.0	17.0		
Stage 5	0.66- 0.42	0.9	9.0	11.0		
Final Filter	<0.42	0.2	2.0	2.0		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink Test Number 4

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Stage 0	>6.3	4.2	60.9	100.0	0.2	4.8
Stage 1	6.3- 3.0	0.5	7.2	39.1	*	*
Stage 2	3.0- 1.8	0.6	8.7	31.9		
Stage 3	1.8- 1.2	0.5	7.2	23.2		
Stage 4	1.2- 0.63	0.2	2.9	16.0		
Stage 5	0.63- 0.40	0.7	10.2	13.1		
Final Filter	<0.40	0.2	2.9	2.9		

* The low total particulate weight combined with the large number of individual fractions, precluded a successful analysis for organic solubles.

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 5

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Cyclone wash	>6.8	3.9	53.4	100.0	0.7	17.9
Stage 1	6.8-3.1	0.6	8.2	46.6	3.4	70.6
Stage 2	3.1-1.8	0.4	5.5	38.4		
Stage 3	1.8-1.3	0.5	6.9	32.9		
Stage 4	1.3-0.66	1.3	17.8	26.0		
Stage 5	0.66-0.42	0.2	2.7	8.2		
Final Filter	<0.42	0.4	5.5	5.5		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 6

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Stage 0	>6.2	9.3	83.8	100.0	0.8	8.6
Stage 1	6.2- 3.0	0.7	6.3	16.2	*	*
Stage 2	3.0- 1.7	<0.1⊕	0.9	9.9		
Stage 3	1.7- 1.2	0.2	1.8	9.0		
Stage 4	1.2- 0.63	0.4	3.6	7.2		
Stage 5	0.63- 0.39	<0.1⊕	0.9	3.6		
Final Filter	<0.39	0.3	2.7	2.7		

⊕ Under limit of detectability

* The low total particulate weight combined with the large number of individual fractions, precluded a successful analysis of organic solubles.

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 7

Fraction	Characteristic Diameter of Particles (µ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Cyclone & Stage 1	>3.1	5.9	81.8	100.0	0.4	5.6
Stage 2	3.1- 1.8	0.1	1.4	18.2		
Stage 3	1.8- 1.3	0.4	5.6	16.8		
Stage 4	1.3- 0.66	0.2	2.8	11.2		
Stage 5	0.66- 0.42	0.2	2.8	8.4		
Final Filter	<0.42	0.4	5.6	5.6		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink Test Number 8

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Cyclone wash	>6.8	6.2	83.8	100.0	0.4	6.5
Stage 1	6.8- 3.1	0.3	4.1	16.2	*	*
Stage 2	3.1- 1.8	0.1	1.4	12.1		
Stage 3	1.8- 1.3	<0.1⊕	1.3	10.8		
Stage 4	1.3- 0.66	0.1	1.4	9.5		
Stage 5	0.66- 0.42	0.2	2.7	8.1		
Final Filter	<0.42	0.4	5.4	5.4		

⊕ Under limit of detectability

* The low total particulate weight combined with the large number of individual fractions, precluded a successful analysis of organic solubles.

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Brink

Test Number 9

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Stage 0	>6.8	6.6	69.4	100.0	<0.2	<3.0
Stage 1	6.8- 3.1	0.5	5.3	30.6	1.1	37.9
Stage 2	3.1- 1.8	0.4	4.2	25.3		
Stage 3	1.8- 1.3	0.6	6.3	21.1		
Stage 4	1.3- 0.66	0.7	7.4	14.8		
Stage 5	0.66- 0.42	0.4	4.2	7.4		
Final Filter	<0.42	0.3	3.2	3.2		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Andersen Test Number 10

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Nozzle wash Stages 0 + 1	>8.2	51.0	54.1	100.0	1.4	2.7
Stage 2	8.2-5.3	14.0	14.8	45.9	0.8	3.4
Stage 3	5.3-3.5	9.4	10.0	31.1		
Stage 4	3.5-2.4	5.3	5.6	21.1		
Stage 5	2.4-1.6	2.6	2.8	15.5		
Stage 6	1.6-0.79	2.4	2.5	12.7	6.5	32.7
Stage 7	0.79-0.48	1.3	1.4	10.2		
Stage 8	0.48-0.32	1.7	1.8	8.8		
Final Filter & Wash	<0.32	6.6	7.0	7.0		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Andersen Test Number 11

Fraction	Characteristic Diameter of Particles (µ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Nozzle wash Stages 0 & 1	>9.2	16.5	51.6	100.0	2.9	17.6
Stage 2	9.2-5.5	3.3	10.3	48.4	0.5	7.9
Stage 3	5.5-3.8	3.0	9.4	38.1		
Stage 4	3.8-2.8	2.9	9.1	28.7	3.0	32.6
Stage 5	2.8-1.7	1.0	3.1	19.6		
Stage 6	1.7-0.83	0.9	2.8	16.5		
Stage 7	0.83-0.52	0.8	2.5	13.7		
Stage 8	0.52-0.35	1.0	3.1	11.2		
Final filter & wash	<0.35	2.6	8.1	8.1		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Andersen Test Number 12

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Nozzle wash Stages 0 & 1	>9.0	8.7	46.5	100.0	1.0	11.5
Stage 2	9.0-5.4	2.0	10.7	53.5	0.4	12.5
Stage 3	5.4-3.6	1.2	6.4	42.8		
Stage 4	3.6-2.7	1.4	7.5	36.4	3.3	48.5
Stage 5	2.7-1.6	0.8	4.3	28.9		
Stage 6	1.6-0.81	1.4	7.5	24.6		
Stage 7	0.81-0.50	0.8	4.3	17.1		
Stage 8	0.50-0.33	0.4	2.1	12.8		
Final filter & wash	<0.33	2.0	10.7	10.7		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Andersen Test Number 13

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Nozzle wash Stages 0 & 1	>8.7	17.4	43.0	100.0	6.3	36.2
Stage 2	8.7-5.4	5.8	14.4	57.0	0.8	7.3
Stage 3	5.4-3.6	5.2	12.9	42.6		
Stage 4	3.6-2.5	4.2	10.4	29.7	3.5	29.2
Stage 5	2.5-1.6	1.8	4.5	19.3		
Stage 6	1.6-0.80	1.9	4.7	14.8		
Stage 7	0.80-0.48	1.1	2.7	10.1		
Stage 8	0.48-0.32	1.1	2.7	7.4		
Final filter & wash	<0.32	1.9	4.7	4.7		

PARTICLE SIZE DISTRIBUTION

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Test Method Andersen Test Number 14

Fraction	Characteristic Diameter of Particles (μ)	Total Sample			Acetone and Cyclohexane Solubles	
		Weight (mg)	Weight (percent)	Cumulative Weight (percent)	Weight (mg)	Percent of Total
Nozzle wash Stages 0 & 1	>8.4	132.7	65.6	100.0	17.0	12.8
Stage 2	8.4-5.4	23.7	11.7	34.4	3.2	8.6
Stage 3	5.4-3.5	13.4	6.6	22.7		
Stage 4	3.5-2.4	4.3	2.2	16.1	13.5	41.5
Stage 5	2.4-1.6	4.0	2.0	13.9		
Stage 6	1.6-0.80	4.5	2.2	11.9		
Stage 7	0.80-0.48	4.3	2.1	9.7		
Stage 8	0.48-0.32	2.8	1.4	7.6		
Final filter & wash	<0.32	12.6	6.2	6.2		

APPENDIX E

EMISSION RESULTS OF GASES AND OTHER MATERIALS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

ACETYLENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/22	4/23
Sampling Period	Start	14:10	14:28	13:08
	Stop	14:11	14:29	13:09
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	(27)	(66)	(49)
	°F	(81)	(150)	(120)
Stack Gas Flowrate	Am^3/min (3)	3500	3500	3610
	DNm^3/min (4)	3360	3360	3480
	ACFM (5)	123,000	123,000	128,000
	DSCFM (6)	119,000	119,000	123,000
Concentration	ppm	1.0	0.2	0.5
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr (7)	0.22	0.04	0.11
	lbs/hr (7)	0.48	0.10	0.25

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(7) Rate during pushing

BENZENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 80-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/24
Sampling Period	Start	16:18	14:42	10:47
	Stop	17:22	16:20	11:47
Sampled Volume	DNm^3 (1)	0.0623	0.104	0.0610
	DSCF (2)	2.20	3.67	2.15
Average Stack Temperature	°C	(24)	(29)	(28)
	°F	(76)	(85)	(83)
Stack Gas Flowrate	Am^3/min (3)	3740	3500	3660
	DNm^3/min (4)	3670	3360	3410
	ACFM (5)	132,000	123,000	129,000
	DSCFM (6)	129,000	119,000	121,000
Concentration	ppm	0.22	0.39	0.68
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	0.16	0.26	0.45
	lbs/hr	0.35	0.57	1.0

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

BENZENE & HOMOLOGUES EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/24
Sampling Period	Start	16:18	14:42	10:47
	Stop	17:22	16:20	11:47
Sampled Volume	DNm^3 (1)	0.0623	0.104	0.0610
	DSCF (2)	2.20	3.67	2.15
Average Stack Temperature	°C	(24)	(29)	(28)
	°F	(76)	(85)	(83)
Stack Gas Flowrate	Am^3/min (3)	3740	3500	3660
	DNm^3/min (4)	3670	3360	3410
	ACFM (5)	132,000	123,000	129,000
	DSCFM (6)	129,000	119,000	121,000
Concentration	ppm	0.31	0.51	0.89
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	0.22	0.33	0.60
	lbs/hr	0.48	0.73	1.3

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

FILTERABLE BENZO(a)PYRENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.22	<0.18	<0.22
	gr/DSCF	<0.0001	<0.00008	<0.0001
Emission Rate	kg/hr	<0.05	<0.04	<0.05
	lbs/hr	<0.11	<0.08	<0.10

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL BENZO(a)PYRENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.34	<0.28	<0.33
	gr/DSCF	<0.0001	<0.0001	<0.0001
Emission Rate	kg/hr	<0.07	<0.06	<0.07
	lbs/hr	<0.16	<0.13	<0.15

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

CARBON MONOXIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4" x 84"

Test Number		1	2	3
Date		4/23	4/23	4/23
Sampling Period	Start	08:30	08:48	08:48
	Stop	08:31	08:49	08:49
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	(19)	(18)	(18)
	°F	(66)	(65)	(65)
Stack Gas Flowrate	Am^3/min (3)	3610	3610	3610
	DNm^3/min (4)	3480	3480	3480
	ACFM (5)	128,000	128,000	128,000
	DSCFM (6)	123,000	123,000	123,000
Concentration	ppm	45	20	15
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr (7)	11.0	4.9	3.7
	lbs/hr (7)	24.2	10.7	8.1

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(7) Rate during pushing

FILTERABLE CHRYSENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.13	<0.11	<0.12
	gr/DSCF	<0.00006	<0.00005	<0.00005
Emission Rate	kg/hr	<0.03	<0.02	<0.03
	lbs/hr	<0.06	<0.05	<0.06

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL CHRYSENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.19	<0.16	<0.19
	gr/DSCF	<0.00008	<0.00007	<0.00008
Emission Rate	kg/hr	<0.04	<0.03	<0.04
	lbs/hr	<0.09	<0.07	<0.09

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

GASEOUS CHLORIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/22
Sampling Period	Start	16:12	09:06	10:40
	Stop	16:44	10:30	11:32
Sampled Volume	DNm^3 (1)	0.892	1.13	1.42
	DSCF (2)	31.5	39.8	50.0
Average Stack Temperature	°C	(23)	(23)	(26)
	°F	(74)	(74)	(79)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	—	—	—
	mg/DNm^3	1.3	0.89	0.83
	gr/DSCF	0.0006	0.0004	0.0004
Emission Rate	kg/hr	0.29	0.19	0.18
	lbs/hr	0.63	0.43	0.40

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

GASEOUS CYANIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/22
Sampling Period	Start	16:12	09:06	10:40
	Stop	16:44	10:30	11:32
Sampled Volume	DNm^3 (1)	0.892	1.13	1.42
	DSCF (2)	31.5	39.8	50.0
Average Stack Temperature	°C	(23)	(23)	(26)
	°F	(74)	(74)	(79)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	—	—	—
	mg/DNm^3	0.004	0.016	0.003
	gr/DSCF	0.000002	0.000007	0.000001
Emission Rate	kg/hr	0.0009	0.003	0.0007
	lbs/hr	0.002	0.008	0.002

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

FILTERABLE CYCLOHEXANE SOLUBLE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle)   Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<32.0	26.3	31.1
	gr/DSCF	<0.014	0.011	0.014
Emission Rate	kg/hr	<7.0	5.5	6.5
	lbs/hr	<15.4	12.1	14.3

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL CYCLOHEXANE SOLUBLE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	32.0	39.4	124
	gr/DSCF	0.014	0.017	0.054
Emission Rate	kg/hr	7.0	8.2	26.0
	lbs/hr	15.4	18.1	57.3

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

FILTERABLE CYCLOHEXANE INSOLUBLES EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<19.2	446	62.2
	gr/DSCF	<0.008	0.195	0.027
Emission Rate	kg/hr	<4.2	93.3	13.0
	lbs/hr	<9.3	206	28.7

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL CYCLOHEXANE INSOLUBLES EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<22.4	446	62.2
	gr/DSCF	<0.010	0.195	0.027
Emission Rate	kg/hr	<4.9	93.3	13.0
	lbs/hr	<10.8	206	28.7

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

ETHENE AND HOMOLOGUES EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/22	4/23
Sampling Period	Start	14:10	14:28	13:08
	Stop	14:11	14:29	13:09
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	(27)	(66)	(49)
	°F	(81)	(150)	(120)
Stack Gas Flowrate	Am^3/min (3)	3500	3500	3610
	DNm^3/min (4)	3360	3360	3480
	ACFM (5)	123,000	123,000	128,000
	DSCFM (6)	119,000	119,000	123,000
Concentration	ppm	4.7	2.3	2.0
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr (7)	1.1	0.54	0.49
	lbs/hr (7)	2.4	1.2	1.1

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(7) Rate during pushing

FILTERABLE FLUORANTHENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.11	0.12	<0.11
	gr/DSCF	<0.00005	0.00005	<0.00005
Emission Rate	kg/hr	<0.02	0.02	<0.02
	lbs/hr	<0.05	0.05	<0.05

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL FLUORANTHENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.16	<0.16	<0.16
	gr/DSCF	<0.00007	<0.00007	<0.00007
Emission Rate	kg/hr	<0.04	<0.03	<0.03
	lbs/hr	<0.08	<0.07	<0.07

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL LIGHT HYDROCARBONS (AS METHANE) EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) **Dimensions:** 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/22	4/23
Sampling Period	**Start**	14:10	14:28	13:08
	Stop	14:11	14:29	13:09
Sampled Volume	**DNm^3** (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	**°C**	(27)	(66)	(49)
	°F	(81)	(150)	(120)
Stack Gas Flowrate	**Am^3/min** (3)	3500	3500	3610
	DNm^3/min (4)	3360	3360	3480
	ACFM (5)	123,000	123,000	128,000
	DSCFM (6)	119,000	119,000	123,000
Concentration	**ppm**	26.6	30.5	15.4
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	**kg/hr** (7)	3.6	4.1	2.1
	lbs/hr (7)	7.9	9.1	4.7

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(7) Rate during pushing

METHANE AND HOMOLOGUES EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/22	4/23
Sampling Period	Start	14:10	14:28	13:08
	Stop	14:11	14:29	13:09
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	(27)	(66)	(49)
	°F	(81)	(150)	(120)
Stack Gas Flowrate	Am^3/min (3)	3500	3500	3610
	DNm^3/min (4)	3360	3360	3480
	ACFM (5)	123,000	123,000	128,000
	DSCFM (6)	119,000	119,000	123,000
Concentration	ppm	22.6	26.8	13.6
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr (7)	3.1	3.6	1.9
	lbs/hr (7)	6.7	8.0	4.2

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(7) Rate during pushing

GASEOUS NITROGEN OXIDES (AS NO_2) EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) **Dimensions:** 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/22
Sampling Period	**Start**	16:12	09:06	10:40
	Stop	16:44	10:30	11:32
Sampled Volume	**DNm^3 (1)**	0.892	1.13	1.42
	DSCF (2)	31.5	39.8	50.0
Average Stack Temperature	**°C**	(23)	(23)	(26)
	°F	(74)	(74)	(79)
Stack Gas Flowrate	**Am^3/min (3)**	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	**ppm**	—	—	—
	mg/DNm^3	0.19	0.12	0.10
	gr/DSCF	0.00008	0.00005	0.00004
Emission Rate	**kg/hr**	0.04	0.03	0.02
	lbs/hr	0.09	0.06	0.05

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

GASEOUS PHENOLICS (AS PHENOL) EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/22
Sampling Period	Start	16:12	09:06	10:40
	Stop	16:44	10:30	11:32
Sampled Volume	DNm^3 (1)	0.892	1.13	1.42
	DSCF (2)	31.5	39.8	50.0
Average Stack Temperature	°C	(23)	(23)	(26)
	°F	(74)	(74)	(79)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	—	—	—
	mg/DNm^3	<1.1	<0.89	<0.71
	gr/DSCF	<0.0005	<0.0004	<0.0003
Emission Rate	kg/hr	<0.25	<0.19	<0.15
	lbs/hr	<0.54	<0.43	<0.34

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

FILTERABLE PYRENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle)   Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.10	<0.14	<0.12
	gr/DSCF	<0.00004	<0.00006	<0.00005
Emission Rate	kg/hr	<0.02	<0.03	<0.03
	lbs/hr	<0.05	<0.07	<0.06

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TOTAL PYRENE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/22	4/23	4/23
Sampling Period	Start	09:09	09:00	13:23
	Stop	10:50	10:14	14:25
Sampled Volume	DNm^3 (1)	0.0626	0.0761	0.0643
	DSCF (2)	2.21	2.69	2.27
Average Stack Temperature	°C	(25)	(23)	(24)
	°F	(77)	(74)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3610	3610
	DNm^3/min (4)	3670	3480	3480
	ACFM (5)	132,000	128,000	128,000
	DSCFM (6)	129,000	123,000	123,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.14	<0.18	<0.17
	gr/DSCF	<0.00006	<0.00008	<0.00007
Emission Rate	kg/hr	<0.03	<0.04	<0.04
	lbs/hr	<0.07	<0.08	<0.08

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

PYRIDINE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/23
Sampling Period	Start	11:11	09:09	13:23
	Stop	13:05	10:50	14:25
Sampled Volume	DNm^3 (1)	0.0616	0.0629	0.0631
	DSCF (2)	2.18	2.22	2.23
Average Stack Temperature	°C	(22)	(25)	(24)
	°F	(72)	(77)	(75)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3610
	DNm^3/min (4)	3670	3670	3480
	ACFM (5)	132,000	132,000	128,000
	DSCFM (6)	129,000	129,000	123,000
Concentration	ppm	<0.02	<0.02	<0.02
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	<0.01	<0.01	<0.01
	lbs/hr	<0.03	<0.03	<0.03

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

GASEOUS SULFATE ($SO_4^=$) EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number			1	2	3
Date			4/21	4/22	4/22
Sampling Period	Start		16:12	09:06	10:40
	Stop		16:44	10:30	11:32
Sampled Volume	DNm^3	(1)	0.892	1.13	1.42
	DSCF	(2)	31.5	39.8	50.0
Average Stack Temperature	°C		(23)	(23)	(26)
	°F		(74)	(74)	(79)
Stack Gas Flowrate	Am^3/min	(3)	3740	3740	3740
	DNm^3/min	(4)	3670	3670	3670
	ACFM	(5)	132,000	132,000	132,000
	DSCFM	(6)	129,000	129,000	129,000
Concentration	ppm		—	—	—
	mg/DNm^3		7.3	1.1	2.5
	gr/DSCF		0.003	0.0005	0.001
Emission Rate	kg/hr		1.6	0.23	0.56
	lbs/hr		3.5	0.51	1.2

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

GASEOUS SULFITE ($SO_3^{=}$) EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/22	4/22
Sampling Period	Start	16:12	09:06	10:40
	Stop	16:44	10:30	11:32
Sampled Volume	DNm^3 (1)	0.892	1.13	1.42
	DSCF (2)	31.5	39.8	50.0
Average Stack Temperature	°C	(23)	(23)	(26)
	°F	(74)	(74)	(79)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	—	—	—
	mg/DNm^3	<0.17	2.3	0.23
	gr/DSCF	<0.00007	0.001	0.0001
Emission Rate	kg/hr	<0.04	0.51	0.05
	lbs/hr	<0.08	1.1	0.11

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

SULFUR TRIOXIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4"x84"

Test Number		1	2	3
Date		4/21	4/21	4/21
Sampling Period	Start	10:45	13:05	17:20
	Stop	11:15	13:35	17:50
Sampled Volume	DNm^3 (1)	0.855	0.835	0.852
	DSCF (2)	30.2	29.5	30.1
Average Stack Temperature	°C	(20)	(22)	(23)
	°F	(68)	(72)	(74)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	2.4	0.79	0.52
	mg/DNm^3	7.9	2.6	1.7
	gr/DSCF	0.003	0.001	0.0008
Emission Rate	kg/hr	1.7	0.58	0.38
	lbs/hr	3.8	1.3	0.84

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

SULFUR DIOXIDE EMISSIONS SUMMARY

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

Source: Coke Shed (Pushing Cycle) Dimensions: 89-3/4" x 84"

Test Number		1	2	3
Date		4/21	4/21	4/21
Sampling Period	Start	10:45	13:05	17:20
	Stop	11:15	13:35	17:50
Sampled Volume	DNm^3 (1)	0.855	0.835	0.852
	DSCF (2)	30.2	29.5	30.1
Average Stack Temperature	°C	(20)	(22)	(23)
	°F	(68)	(72)	(74)
Stack Gas Flowrate	Am^3/min (3)	3740	3740	3740
	DNm^3/min (4)	3670	3670	3670
	ACFM (5)	132,000	132,000	132,000
	DSCFM (6)	129,000	129,000	129,000
Concentration	ppm	0.32	0.83	0.65
	mg/DNm^3	0.86	2.2	1.7
	gr/DSCF	0.0004	0.001	0.0008
Emission Rate	kg/hr	0.19	0.49	0.38
	lbs/hr	0.42	1.1	0.84

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

APPENDIX F

SAMPLING SUMMARY SHEETS
PUSHING AND NON-PUSHING CYCLE PARTICULATE TESTS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

SAMPLING SUMMARY SHEET

Plant Great Lakes Carbon Corporation Location St. Louis, Missouri

Sampled Source Coke Shed (Pushing Cycle)

Run	Date	N_p	P_m	Pb	V_m	T_m	$V_{m_{std}}$	V_w	$V_{w_{gas}}$	%M	M_d
1	4/21-22/75	24	2.47	30.02	243.1	88	236.5	50	2.36	0.99	0.990
2	4/22/75	24	2.23	29.97	157.6	102	149.1	24	1.13	0.75	0.992
3	4/23/75	24	2.39	29.55	161.5	89	154.3	43	2.03	1.3	0.987
4	4/24/75	24	2.34	29.55	101.7	94	96.3	41	1.93	2.0	0.980

Run	MW_d	MW	P_{st}	P_s	C_p	$\sqrt{\Delta P_s X (T_s+460)}^c$	V_s	T_s	T_t	D_n	%I
1	28.85	28.74	-0.012	30.01	0.845	17.14	2525	75	288	0.246	99.9
2	28.85	28.76	-0.012	29.96	0.845	16.00	2359	85	192	0.246	102.9
3	28.85	28.71	-0.012	29.54	0.845	16.40	2437	74	197	0.246	100.4
4	28.85	28.63	-0.014	29.54	0.847	16.61	2471	88	125	0.246	100.6

$$V_{m_{std}} = \frac{17.65 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}}$$

$$V_{w_{gas}} = 0.0471 \times V_w$$

$$M_d = \frac{100 - \%M}{100}$$

$$MW_d = (\%CO_2 \times \tfrac{44}{100}) + (\%O_2 \times \tfrac{32}{100}) + (\%CO + \%N_2) \times \tfrac{28}{100}$$

$$MW = MW_d \times M_d + 18\,(1 - M_d)$$

$$P_s = P_b \pm P_{st}$$

$$V_s = 5128.8 \times C_p \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{1{,}032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2}$$

N_p	Total No. of Sampling Points
P_m	Average Orifice Pressure Drop, in. H_2O
P_b	Barometric Pressure, in. Hg. Absolute
V_m	Volume of Dry Gas at Meter Conditions, DCF
T_m	Average Meter Temperature, °F
$V_{m_{std}}$	Volume of Dry Gas at STP, DSCF^a
V_w	Total H_2O Collected in Impingers and Silica Gel, ml
$V_{w_{gas}}$	Volume of Water Vapor Collected at STP, SCF^b
% M	% Moisture by Volume
M_d	Mole Fraction of Dry Gas
% CO_2	Volume % Dry
% O_2	Volume % Dry
% CO	Volume % Dry
% N_2	Volume % Dry
MW_d	Molecular Weight of Stack Gas, Dry Basis
MW	Molecular Weight of Stack Gas, Wet Basis
P_{st}	Static Pressure of Stack Gas, in. Hg
P_s	Stack Gas Pressure, in. Hg Absolute
C_p	Pitot Tube Coefficient
V_s	Stack Gas Velocity at Stack Conditions, fpm
T_s	Average Stack Temperature °F
T_t	Net Time of Test, Min.
D_n	Sampling Nozzle Diameter, ft
% I	Percent Isokinetic

^{a} Dry standard cubic feet at 68°F, 29.92 in. Hg.

^{b} Standard conditions at 68°F, 29.92 in. Hg.

^{c} $\sqrt{\Delta P_s \times (T_s + 460)}$ is determined by averaging the square root of the product of the velocity head (ΔP_s) and the absolute stack temperature from each sampling point.

SAMPLING SUMMARY SHEET

Plant Great Lakes Carbon Corporation   Location St. Louis, Missouri

Sampled Source Coke Shed (Non-pushing Cycle)

Run	Date	N_p	P_m	P_b	V_m	T_m	$V_{m_{std}}$	V_w	$V_{w_{gas}}$	%M	M_d
1	4/21/75	24	2.47	30.02	143.0	95	137.3	22	1.04	0.75	0.992
2	4/22/75	24	2.36	29.97	161.4	92	155.6	35	1.65	1.1	0.989
3	4/23/75	24	2.70	29.55	173.8	91	165.6	68	3.20	1.9	0.981

Run	MW_d	MW	P_{st}	P_s	C_p	$\sqrt{\Delta P_s X (T_s+460)}^{c}$	V_s	T_s	T_t	D_n	%I
1	28.85	28.76	-0.012	30.01	0.847	16.69	2464	69	168	0.247	99.7
2	28.85	28.73	-0.012	29.96	0.847	16.85	2491	85	192	0.247	101.2
3	28.85	28.64	-0.012	29.54	0.847	17.54	2616	70	192	0.247	102.0

$$V_{m_{std}} = \frac{17.65 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)} \qquad \%M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}}$$

$$V_{w_{gas}} = 0.0471 \times V_w \qquad M_d = \frac{100 - \%M}{100}$$

$$MW_d = (\%CO_2 \times \frac{44}{100}) + (\%O_2 \times \frac{32}{100}) + (\%CO + \%N_2) \times \frac{28}{100}$$

$$MW = MW_d \times M_d + 18\,(1 - M_d)$$

$$P_s = P_b \pm P_{st}$$

$$V_s = 5128.8 \times Cp \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{1{,}032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2}$$

N_p	Total No. of Sampling Points
P_m	Average Orifice Pressure Drop, in. H_2O
P_b	Barometric Pressure, in. Hg. Absolute
V_m	Volume of Dry Gas at Meter Conditions, DCF
T_m	Average Meter Temperature, °F
$V_{m_{std}}$	Volume of Dry Gas at STP, DSCF[a]
V_w	Total H_2O Collected in Impingers and Silica Gel, ml
$V_{w_{gas}}$	Volume of Water Vapor Collected at STP, SCF[b]
% M	% Moisture by Volume
M_d	Mole Fraction of Dry Gas
% CO_2	Volume % Dry
% O_2	Volume % Dry
% CO	Volume % Dry
% N_2	Volume % Dry
MW_d	Molecular Weight of Stack Gas, Dry Basis
MW	Molecular Weight of Stack Gas, Wet Basis
P_{st}	Static Pressure of Stack Gas, in. Hg
P_s	Stack Gas Pressure, in. Hg Absolute
C_p	Pitot Tube Coefficient
V_s	Stack Gas Velocity at Stack Conditions, fpm.
T_s	Average Stack Temperature °F
T_t	Net Time of Test, Min.
D_n	Sampling Nozzle Diameter, in.
% I	Percent Isokinetic

[a] Dry standard cubic feet at 68°F, 29.92 in. Hg.

[b] Standard conditions at 68°F, 29.92 in. Hg.

[c] $\sqrt{\Delta P_s \times (T_s + 460)}$ is determined by averaging the square root of the product of the velocity head (ΔP_s) and the absolute stack temperature from each sampling point.

APPENDIX G

X-RAY FLUORESCENCE SPECTROMETER ANALYSIS OF COKE-SIDE PARTICULATE EMISSIONS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

X-RAY FLUORESCENCE SPECTROMETER ANALYSIS OF COKE-SIDE PARTICULATE EMISSIONS

ANALYSIS TECHNIQUE

A Siemens multichannel wavelength x-ray fluorescence spectrometer has been adapted by EPA's Environmental Research Center/RTP for rapid analysis of particulate samples(1). The system consists of sixteen fixed-wavelength spectrometers setup for analysis of 16 preselected elements and a computer-operated scanning channel used to determine additional elements that might be desired. The EPA simultaneous wavelength x-ray spectrometer has been specially designed for analysis of filter deposited samples of particulate matter. The spectrometer is being used by EPA to determine the elemental composition of particulate emissions collected from mobile sources, power plants, incinerators, and chemical process industries, and from ambient air at various locations. Table 1 lists typical data.

COLLECTION OF COKE-SIDE PARTICULATE EMISSIONS SAMPLES

A special sampling train consisting of a 2-mm nozzle, probe, and 47-mm filter holder, and an air pump with 2.3 lpm flow orifice was used to collect samples of push emissions at the GLC Coke Plant. The particulate matter was sampled from the exhaust duct airstream under isokinetic flow conditions and collected on cellulose-acetate filter matrix. A total of five filter samples were collected, all during peak push periods on April 24, 1975. The sample collection periods varied from 15 seconds to 3 minutes. At least two of the samples were collected during "green" pushes.

X-RAY FLUORESCENCE ANALYSIS RESULTS

Tables 2-7 presents the XRF analysis of filterable particulate emissions produced during the pushing of the coke oven. The data results are displayed in the original computer printout format. Footnotes have been included in the tables where explanation of chemical symbols or measurement units are appropriate.

These analysis indicated that the non-carbon portion of the collected particulate contained the elements chlorine, sulfur, silicon, and aluminum with small amounts of calcium and iron. The other 20 trace elements analyzed in the coke-side particulate emission samples were present in concentrations below the minimum detection limits of the XRF analytical procedure.

Although the filters were not analyzed gravimetrically, the total weight of the material collected can be roughly estimated based on the volume of air sampled and an assumed average grain loading for the peak push period. In Table 1, the concentration of the collective trace elements is compared with the estimated gross concentration of the total particulate filter catch for each of three samples. The data indicates the composition of coke-side emissions is mainly carbonaceous material, ranging from 92 to 99 percent carbon by weight.

Table 1. ESTIMATED PERCENT CARBON COMPOSITION OF COKE-SIDE PARTICULATE EMISSIONS

		TOTAL WEIGHT (μg/cm^2)		
Filter No.	Sampling Period	Trace Elements	Sample	% Carbon
D-2A	15 sec.	2.7	32.8	92
B-3	30 sec.	3.3	65.5	95
D-2B	30 sec.	3.0	65.5	96
C-4	30 sec.	3.4	65.5	95
A-5	3 min.	4.5	393.0	99

The data in Table 1 shows a trend towards proportionally higher concentrations of trace elements in the samples with the shortest sampling time. This initially suggested that the amount of material collected on the filter for the 15 and 30-second samples may have been insufficient for accurate XRF analysis and that the collective sample concentration reported for all of the trace elements in these samples could be positive baised. The filter samples were collected primarily for light microscopic examination and the sampling times were purposely kept low to prevent appreciable particulate buildup on the filter surface. However, the microscopic examination results, which are reported in Appendix H , tend to collaborate the XRF data results in that the relative amount of trace elements present in sample D-2A was unequivalocity observed to be substantially greater than in the longer term Sample A-5. The greenness of the push does not appear to a deciding factor since all three of the 30-second samples contained approximately the same amount of trace elements and only D-2B was designated a green push sample.

No explanation can be offered for at this time for the greater percentage of non-carbonaceous material in some of the samples. Nevertheless, the XPF analysis results for sample A-5 is probably more representative of the composition of coke-side particulate emissions and quantities of trace elements released during the typical peak push period since the 3-minute sampling time was sufficiently long to include all of the coke push.

REFERENCE

(1) Bennet, R., Wagman, J. and Knapp, K. The Application of a Multichannel Fixed and Sequential Spectrometer System to the Analysis of Air Pollution Particulate Samples, EPA, Research Triangle Park, N. C. October 1975.

TABLE 1. TYPICAL XRF ANALYSIS DATA FOR AIR POLLUTION PARTICULATE SAMPLES[1]

Concentration: micrograms/cm^2

Element	Coal Power Plant Flyash		Ambient Air	
Sample	#5	#10	#7-24	#10-04
F	0.29	0.15	-	0.09
Na	0.42	0.35	-	0.09
Mg	2.0	1.2	0.06	0.14
Al	103.	48.	1.20	5.30
Si	55.	26.	1.60	7.60
P	0.54	1.0	-	0.18
S	7.8	7.8	3.20	1.77
Cl	-	-	0.15	0.47
K	-	-	0.47	2.06
Ca	-	4.9	0.90	2.67
Ti	3.6	1.5	0.08	0.16
V	0.55	0.25	-	0.03
Cr	23.	15.	-	-
Fe	20.2	9.2	0.70	2.73
Ni	0.03	-	-	-
Zn	4.6	0.13	0.05	0.16
Br	0.89	-	-	0.75
Cd	0.02	0.007	0.007	0.04
Ba	0.62	0.33	0.04	0.10
Pb	1.7	1.1	0.23	3.00

---

[1] Data reported in Reference No. 1.

TABLE 2. BLANK FILTER ANALYSIS AND OTHER XRF ANALYSIS INFORMATION

```
BLANK 1
ELEMENT          TIME           CPS            DETECTION LIMIT
CR                20             32.4          .1                CR
PB               100            688.6          .537              PB
MN               100            344.14         .32911            MN
AS               100           7459.88         .8178             AS
HG               100            478.92         .558              HG
BR               100           2529.25         .22257            BR
P                100             22.8          .0078             P
SI               100              2.06         .00696            SI
CD               100              3.28         .00287            CD
AL               100             .65           .00613            AL
S                100            118.74         .00677            S
NA               100             .21           .02814            NA
F                100              2.09         .17721            F
MG               100              1.05         .00455            MG
K                100            173.8          .00593            K
CL               100            180.29         .06602            CL
AR                20             54.3          .2886574E-1       AR
PT                20             60.55         .3431             PT
ZN                35             21.71429      .09715            ZN
CU                20            491.25         .34334            CU
NI                20             38.85         .02309            NI
FE                20             30.05         .10791            FE
V                 20             21.75         .02739            V
TI                20             13.7          .00568            TI
BA                20              8.55         .00689            BA
CA                20            222.75         .02435            CA
```

CPS - Counts per second

Detection Limit - Minimun detection limits ($\mu g/cm^2$)

TABLE 3. SAMPLE NO. A-5

SAMPLE TIME - 3 MINUTES (COMPLETE PUSH)

```
SAMPLE 3
ELEMENT        RAW CPS      CPS-BLANK     CONCENTRATION
CR              33.7         1.3          .1737039E-1   CR *
PB              726.62       38.02        .2292636      PB *
MN              371.06       26.92        .1536315      MN *
AS              7511.7       51.82        .4597547      AS *
HG              493.3        14.38        .2489638      HG *
BR              2601.11      71.86        .1427485      BR *
P               24           1.2          .8959954E-2   P
SI              57.67        55.61        .4788388      SI
CD              3.74         .46          .2658515E-2   CD *
AL              33.7         33.05        .4893052      AL
S               265.79       147.05       .5249397      S
NA              .55          .34          .6369941E-1   NA
F               1.86         -.23         ND            F  *
MG              3.54         2.49         .2422284E-1   MG
K               258.48       84.68        .6981857E-1   K
CL              344.6        164.31       .647025       CL
AR              56.7         2.4          .1481483E-1   AR *
PT              68.2         7.65         .1123083      PT *
ZN              35.37143     13.65714     .0648295      ZN *
CU              544.8        53.55        .283635       CU *
NI              47.4         8.55         .5894897E-1   NI
FE              61.45        31.4         .2360902      FE
V               26.7         4.95         .2748504E-1   V
TI              52.3         38.6         .4507459E-1   TI
BA              14           5.45         .0218         BA
CA              348.8        126.05       .1435368      CA
```

CPS-Blank - Blank reading subtracted from sample reading.

E-1 - Preceeding concentration to be multiplied by 10^{-1}.

ND - Not detectable.

As/Ar - Arsenic element analyzed by two methods.

* - Below minimun detection limits.

Concentration - Units of $\mu g/cm^2$ filter area.

TABLE 4. SAMPLE NO. B-3

SAMPLE TIME - 30 SECONDS

```
SAMPLE
ELEMENT      RAW CPS       CPS-BLANK      CONCENTRATION
CR            33.45         1.05          .1402993E-1   CR *
PB           758.55         69.95         .421804       PB *
MN           388.85         44.71         .2551583      MN *
AS           7509.85        49.97         .4433412      AS *
HG           502.3          23.38         .4047825      HG *
BR           2592.39        63.14         .1254264      BR *
P             22.53         -.27          ND            P  *
SI            19.67         17.61         .1516337      SI
CD            3.48          .2            .1155876E-2   CD *
AL            14.45         13.8          .170905       AL
S            152.65         33.91         .1210521      S
NA            .29           .08           .0149881      NA *
F             2.07          -.02          ND            F  *
MG            1.72          .67           .6517793E-2   MG
K            204.59         30.79         .2538632E-1   K
CL           246.61         66.32         .2611569      CL
AR            63.3          9             .0525556      AR
PT            75.15         14.6          .21434        PT *
ZN            29,57143      7.857143      .3729731E-1   ZN *
CU           530.55         39.3          .2081579      CU *
NI            50            11.15         .7687498E-1   NI
FE            51.7          21.65         .162782       FE
V             29.4          7.65          .4247687E-1   V
TI            29.65         15.95         .1862538E-1   TI
BA            11.7          3.15          .0126         BA
CA           250.4          27.65         .3148587E-1   CA
```

TABLE 5. SAMPLE NO. C-4

SAMPLE TIME - 30 SECONDS

```
SAMPLE 5
ELEMENT          RAW CPS        CPS-BLANK        CONCENTRATION
CR                34.55          2.15            .2872795E-1  CR *
PB               734.88         46.28            .2790721     PB *
MN               378.5          34.36            .1960913     MN *
AS              7523.45         63.57            .5640024     AS *
HG               496.06         17.14            .2967482     HG *
BR              2609.83         80.58            .1600706     BR *
P                 23.23          .43             .3211065E-2  P  *
SI                25.46         23.4             .2014695     SI
CD                 3.52          .24             .1387051E-2  CD *
AL                15.36         14.71            .1821749     AL
S                187.93         69.19            .2469948     S
NA                .54            .33             .0618259     NA
F                 1.99          -.1              ND           F  *
MG                3.49           2.44            .2373644E-1  MG
K                217.44         43.64            .3598113E-1  K
CL               275.88         95.59            .3764172     CL
AR                60.2           5.9             .3445311E-1  AR
PT                71            10.45            .1534146     PT *
ZN                27             5.285714        .2509092E-1  ZN *
CU               535.05         43.8             .2319927     CU *
NI                44.1           5.25            .3619674E-1  NI
FE                45            14.95            .112406      FE
V                 26.6           4.35            .2692978E-1  V  *
TI                29.4          15.7             .1833345E-1  TI
BA                11.65          3.1             .0124        BA
CA               339.6         117.05            .1332683     CA
```

TABLE 6. SAMPLE NO. D-2A

SAMPLE TIME - 15 SECONDS (GREEN PUSH)

```
SAMPLE 1
ELEMENT          RAW CPS        CPS-BLANK        CONCENTRATION
CR                32.95          .55             .7349011E-2  CR *
PB                699.41         12.81           .6518516E-1  PB *
MN                351.84         7.7             .4394362E-1  MN *
AS                7476.02        16.14           .1431965     AS *
HG                479.6          .6800003        .1177298E-1  HG *
BR                2604.29        75.04           .1490655     BR *
P                 23.05          .25             .1866657E-2  P  *
SI                25.2           23.14           .1992507     SI
CD                3.5            .22             .1271464E-2  CD *
AL                14.77          14.12           .1748681     AL
S                 227.39         108.65          .3878592     S
NA                .54            .33             .0618259     NA
F                 2.02           -.07            ND           F  *
MG                3.3            2.25            .2188811E-1  MG
K                 212            38.2            .3149586E-1  K
CL                406.16         225.87          .8894378     CL
AR                53.65          -.65            ND           AR *
PT                62.85          2.3             .3376589E-1  PT *
ZN                23.25714       1.542857        .7323835E-2  ZN *
CU                523.7          32.45           .1718759     CU *
NI                42.65          3.5             .2619954E-1  NI
FE                44.55          14.5            .1090226     FE
V                 25.9           4.15            .2304301E-1  V  *
TI                33.1           19.4            .2265487E-1  TI
BA                9.75           1.2             .2246        BA *
CA                324.9          122.15          .1163212     CA
```

TABLE 7. SAMPLE NO. D-2B

SAMPLE TIME - 30 SECONDS (GREEN PUSH)

```
SAMPLE 2
ELEMENT         RAW CPS        CPS-BLANK        CONCENTRATION
CR               30.9          -1.5             ND             CR *
PB               717.84         29.24           .1763195       PB *
MN               364.23         28.09           .1146529       MN *
AS               7460.28        .4008015        .3548872E-2    AS *
HG               485.82         6.9             .1194611       HG *
BR               2548.37        19.12           .3798151E-1    BR *
P                24.77          1.97            .1478926E-1    P
SI               29.75          27.69           .2384292       SI
CD               3.32           .04             .2311752E-3    CD *
AL               17.93          17.28           .2148828       AL
S                217.04         98.3            .3509118       S
NA               .56            .35             .6557292E-1    NA
F                2.18           .89             .4100336E-1    F  *
MG               3.53           2.48            .2412556E-1    MG
K                226.26         52.46           .4325321E-1    K
CL               291.95         111.66          .4396982       CL
AR               57.1           2.8             .1635063E-1    AR *
PT               66.5           5.95            .0873509       PT *
ZN               25.14286       3.428571        .1627519E-1    ZN *
CU               521.15         29.9            .1583695       CU *
NI               43.95          5.1             .3516254E-1    NI
FE               53.2           23.15           .1740602       FE
V                24.8           3.05            .1693522E-1    V  *
TI               31.4           17.7            .2066892E-1    TI
BA               10.65          2.1             .2084          BA
CA               344.25         121.5           .1383556       CA
```

H-i

APPENDIX H

MICROSCOPIC ANALYSIS OF COKE-SIDE PARTICULATE EMISSIONS

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

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November 5, 1975

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Subject: "Coke Oven Emissions"
Letter Report on IITRI Project No. C6333, Task 1

We have completed the analysis of your five Millipore filter samples of coke oven emissions from Great Lakes Carbon. The analysis techniques, results, and recommendations are presented below. Photomicrographs are included at the end of this report.

ANALYSIS TECHNIQUES

The bulk of the sample analyses were performed with the optical microscope. A small pie-shaped section was cut from each filter and was mounted in immersion oil ($n_D = 1.515$) on a glass slide under a cover slip. Reflected light and polarized light were employed to perform particle characterization and sizing.

Supplementary analysis was performed on four of the five samples with the scanning electron microscope (SEM). A small section of each filter was coated with a thin layer of evaporated carbon to make the section electrically conductive. In addition to the particle size information supplied by the secondary electron image, information on particle elemental composition was obtained with the energy dispersive x-ray analyzer attachment.

RESULTS

The particles in each sample were classified into eight different categories based on particle morphology, color, birefringence, and surface characteristics. The particle types are described below:

Fly Ash -- Colorless to pale green or yellow, partially to completely formed glassy spheres. These particles are formed by heat fusion of coal minerals and typically consist of primarily aluminum, silicon, potassium, and calcium. Other mineral components such as sodium, magnesium, and titanium are also often found. Fly ash color is due to the presence of metals such as iron and chromium in solid solution.

Fe_xO_x Iron oxides -- FeO, Fe_2O_3, Fe_3O_4 are typically found in coal. The iron appears as hematite particles and partially fused spheres, magnetic oxide spheres, and hydrated iron oxide particles. Color is the key to identification of these particles.

Minerals -- A variety of mostly silicate minerals are found in coal. The small particle size of most of the minerals found in the samples made identification as to mineral type by optical microscopy impossible. The SEM x-ray analyzer could merely confirm that the few mineral particles present were primarily aluminosilicates.

Coal -- These particles range in shape from essentially equant chunks with sharp, angular edges to thin, flat flakes, also with sharp, angular edges. The thicker particles are, of course, opaque and black in color; the thinner particles appear red under transmitted light. Under reflected light, coal is distinguished from other carbonaceous particles by its very smooth, black, lustrous surface.

Partially coked coal -- Particles in various stages of coking were present in all samples. As coal begins to coke, microfissures and air bubbles form on the particle surfaces due to escaping gases. These disturbances of the particle surface texture cause the particles to appear silvery in reflected light due to light diffraction. In addition to surface texture changes, particle morphology changes occur also. Particles lose their sharp, angular edges as they begin to melt. As more of the volatilized hydrocarbons escape, particles become lacey and holey in appearance.

Coke -- The larger (> 3 μm) coke particles are quite obvious by their morphology and surface characteristics. They appear as gray-black sponge-like particles.

Fine Carbonaceous Particles -- Carbonaceous particles below 3 μm are practically impossible to classify as coal, coke, or partially coked coal. If the particles are thin enough to transmit light, then they can be identified (as coal if they are red). If the particles are spherical in shape, then they can be identified as at least partially coked. Submicron particles appearing in fluffy clusters are most likely completely pyrolized, and can therefore be classed as coke.

Vitreous Flakes and Balls -- This particle type forms from the slow combustion of the low volatile components of coal. The flakes appear as spiney fragments with thin vitreous films joining the spines. The vitreous balls appear with either the thin joining films intact, or as skeletal structures because of complete combustion of the more volatile film.

A-5 3 minute sampling Normal Push

The sample was heavily loaded with the various types described above. Table 1 presents size distribution data and approximate relative concentrations of the particle types.

Coking appeared to be fairly extensive in the sample as evidenced by the extremely fine coke particles present (down to .01 μm), some of which appeared in fluffy clusters. Most of the larger particles also showed quite a bit of coking, as evidenced by the lacey edges on the particles.

The mineral content was extremely low in this sample. Most of the minerals seen were extremely small in size. Aluminum, silicon, sulfur, chlorine, potassium, calcium, titanium, chromium, and iron were detected by the SEM x-ray analyzer in various individual particles. Sulfur was the only element which was present in sufficient concentration to be detected by a large area x-ray scan of the sample.

B-3 30 second sampling Normal Push

The sample was very lightly loaded with the various particle types. Due to the shorter sampling time, the proportion of submicron particles is lower on this sample compared to the A-5 sample.

Again the particle morphologies indicate good coking; therefore, the hydrocarbon content should be low.

Mineral content was slightly greater than the A-5 sample. Concentrations of the inorganic elements were high enough only in individual particles to be detected by SEM x-ray; a large area x-ray scan did not reveal the presence of any

Table 1

PARTICLE CHARACTERIZATION

Particle Type	Normal Push									Green Push		
	A-5			B-3			C-4			D-2		
	Size Range(μm)	Size Mode(μm)	Conc*	Size Range(μm)	Size Mode(μm)	Conc*	Size Range(μm)	Size Mode(μm)	Conc*	Size Range(μm)	Size Mode(μm)	Conc*
Fly Ash	0.2 - 12	0.4	t	0.2 - 5	0.8	t	0.2 - 5	0.4	t	0.2- 32	1	t
Fe_xO_x	0.4 - 7	0.8	t	0.2 - 16	1	t	0.2 - 16	0.8	t	0.2- 24	1	t
Minerals	0.2 - 24	2	m	0.2 - 72	3	m	0.2 - 24	2	m	0.2- 56	3	m
Coal	<0.8 - 56	4	M	<0.8 - 64	5	M	<0.8 - 56	3	M	<0.8-960	5	M
Partially Coked Coal	<0.2 - 72	3	P	<0.2 -160	3	P	<0.2 - 72	3	P	<0.2-720	4	P
Coke	<0.2 -110	3	P	<0.2 -160	3	P	<0.2 -110	4	P	<0.2-160	3	P
Fines	0.01- 3	0.08	M	0.01- 3	0.08	M	0.01- 3	0.08	m-M	0.1- 3	0.5	M
Virteous Flakes	5 - 12	10	t	5 - 81	16	t	4 - 16	8	t	4 - 56	12	m

* P = > 25% by weight

M = 5-25%

m = 0.5-5

t = < 0.5

elements higher than sodium in atomic number. Elements seen in individual particles of this sample not seen in A-5 were sodium and magnesium.

C-4 30 second sampling Normal Push

The sample was lightly loaded with the various particle types. A slightly greater percent of submicron particles was present in this sample compared to B-3.

This sample showed the greatest degree of coking of any of the samples examined. Particle morphologies, as well as the absence of a great number of the larger uncoked coal particles allows this statement to be made.

The mineral content of this sample was essentially similar to that of A-5.

D-2 15 and 30 second sampling Green Push

The two green push samples were essentially identical in concentration and size ranges of the various particle types. Both samples were also fairly heavily loaded with particles.

Both samples contained a higher proportion of coal particles and particles which were only slightly coked as compared to the three normal push samples. The surface texture of the particles, however, indicated that all particles had been exposed to heat for only a short time immediately before sampling.

The carbonaceous particles in the very small sizes (less than 0.5 μm) were lower in concentration than in the normal push samples. However, the size range 0.5-1 μm showed a greater concentration in the green push as compared to the normal push samples. The particles in this size range were more angular for the green push samples as compared to the normal push samples. These findings, as well as the lack of much lacey structure in the larger particles, indicates that coking was rather incomplete in these samples.

The mineral content was also higher in the green push samples. Definite peaks for silicon, aluminum, sulfur, and calcium could be seen in a large area x-ray scan. This indicates a definite higher concentration of these elements in the green as compared to the normal push samples. Individual particles contained the same elements seen in the normal push sample.

CONCLUSIONS

It is difficult to draw conclusions on the difference between normal and green coke pushes when so few samples are examined. However, based on the assumptions that these samples are truly representative of the two types of pushes, a few conclusions can be drawn.

If one assumes that the B-3 and C-4 samples were obtained under the same conditions (i.e., same distance from the oven door, same flow rates, etc.) as the D-2 30 second sample, then it is quite obvious that a green push produces a greater proportion of fine particles (less than 3 μm) than a normal push.

The green push also contains a greater proportion of uncoked and slightly coked material. The higher concentration of particles in the 0.5-1 μm range in the green push, as well as particle morphologies, indicates this.

RECOMMENDATIONS

Future samplings should include size selective sampling of the green and normal pushes. Several samples of each type of push should be taken.

One of the problems encountered in determining particle sizes was due to the heavy loading of submicron particles and the type of filter used. Millipore filter has a highly textured surface and is therefore a poor substrate for particle analysis on the SEM. It is suggested that future samplings include collection of samples specifically for microscope examination. The Millipore filter should be used for collection of a sample for optical microscopy. A Nuclepore filter

(Nuclepore Corp., 7035 Commerce Circle, Pleasonton, Calif. 94566, 415-462-2230) should be used to collect samples for scanning electron microscope analysis. The Nuclepore filter has a very flat, smooth surface making it ideal for SEM analysis.

If you have any questions on our analyses, please do not hesitate to contact us.

Respectfully submitted,
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LIST OF FIGURES

1. A-5 163X; T* and R**; Partially coked coal flake (bottom) and completely coked particle showing lacey texture (top).

2. A-5 163X; Typical field of view showing shiney flakes of partially coked particles, angular coal fragments, large lacey coke particles, and fine carbonaceous particles.

3. A-5 420X; T*; Fluffy agglomerate of fine carbonaceous particles in the center.

4. A-5 1,000X; SEI***; Typical flakey, equant and fluffy clusters of carbonaceous particles; the background is composed of the other submicron carbonaceous particles coating the textured Millipore surface.

5. A-5 30,000X; SEI***; Edge of fluffy cluster in center of Figure 4; note rounded nature of the particles.

6. B-3 163X; T* and R**; Typical particles; note low concentration.

7. B-3 1,000X; SEI***; Although there are significantly fewer fine particles present, the background in this picture appears the same as in Figure 4 - the texture of the Millipore.

8. C-4 163X; T* and R**; Note lacey structure of most of the particles.

9. C-4 420X; T*.

10. C-4 1,000X; SEI***.

11. D-2 30 sec.; 65X; T* and R**; Some large slightly coked particles found along the edge of the filter.

12. D-2 30 sec.; 163X; T* and R**; When compared to Figures 6 and 8 which are comparable sampling times, it is obvious the green push (D-2) produces more fine particles than a normal push if in fact sampling conditions for the two pushes were identical.

13. D-2 30 sec.; 420X; T*; The small particles here are quite angular and are most abundant in the 0.5-1 μm range.

14. D-2 30 sec.; 1,000X; SEI***.

15. D-2 15 sec.; 163X.

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* T = plane polarized (transmitted) light
** R = reflected light
*** SEI = secondary electron image

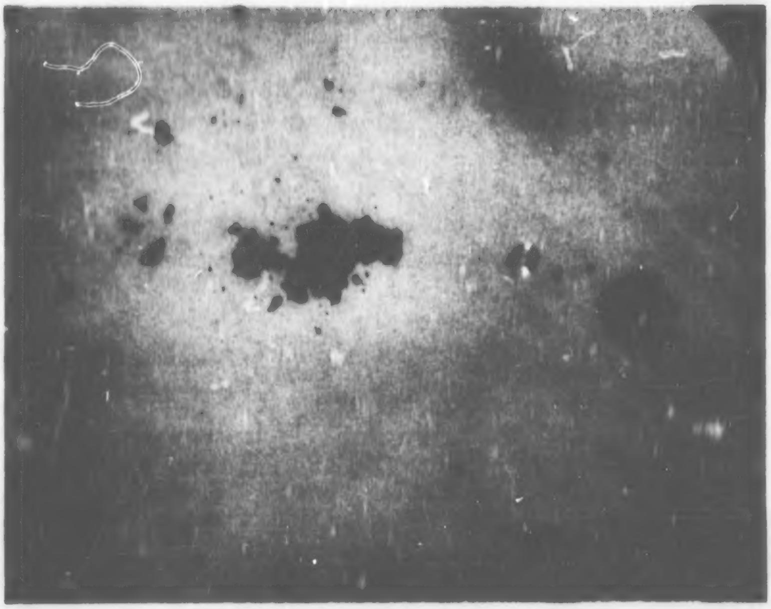


Figure 1

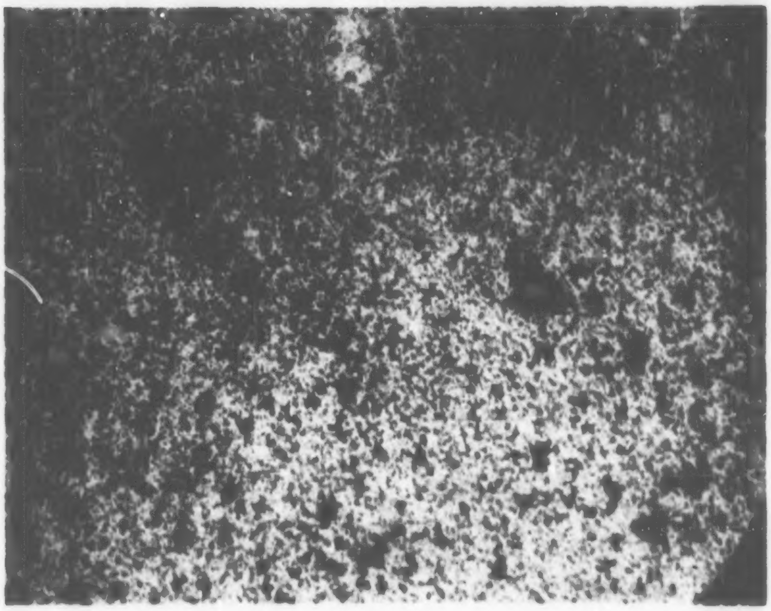


Figure 2

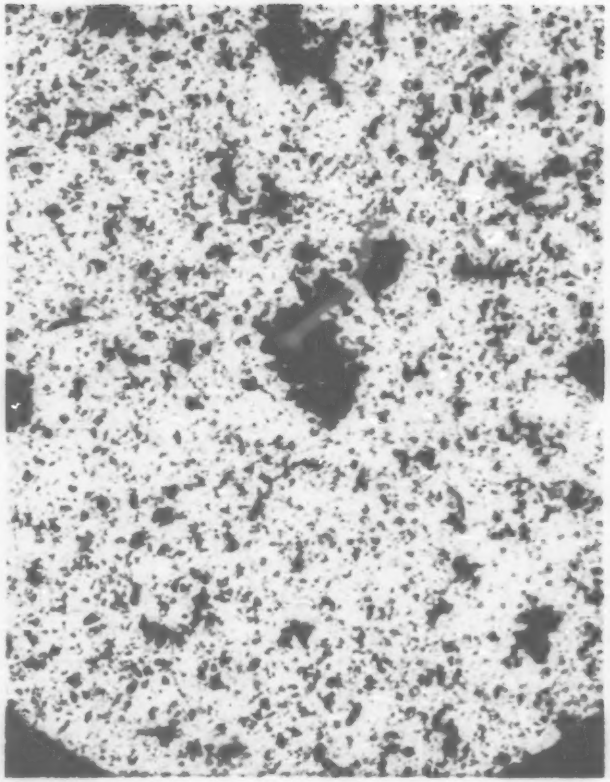
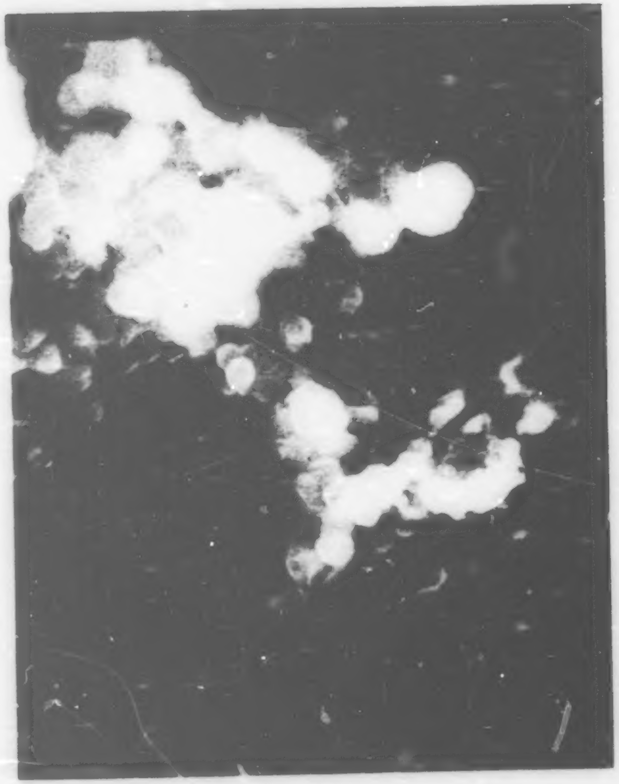


Figure 3

Figure 4



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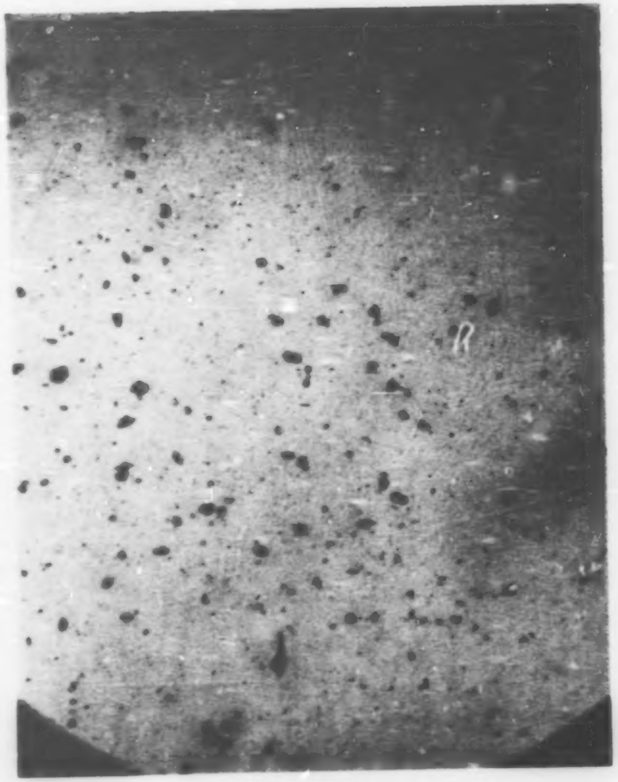

Figure 6

Figure 7

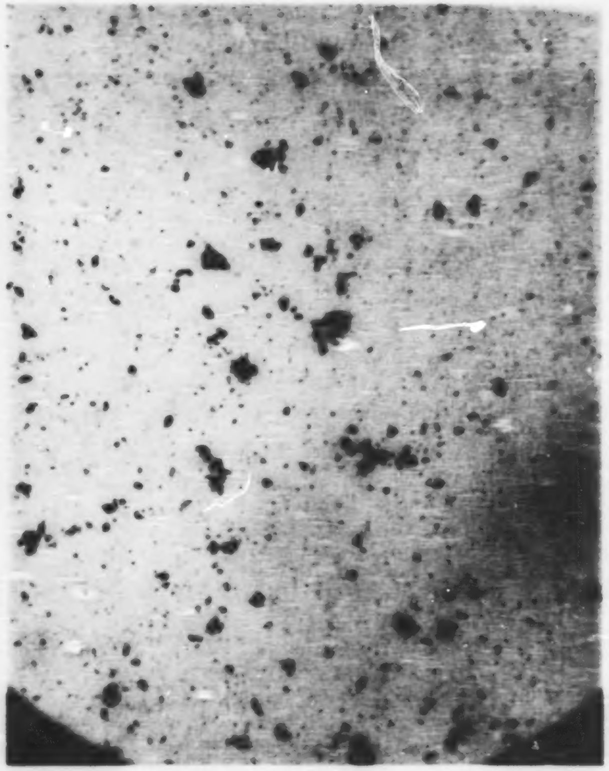

Figure 8

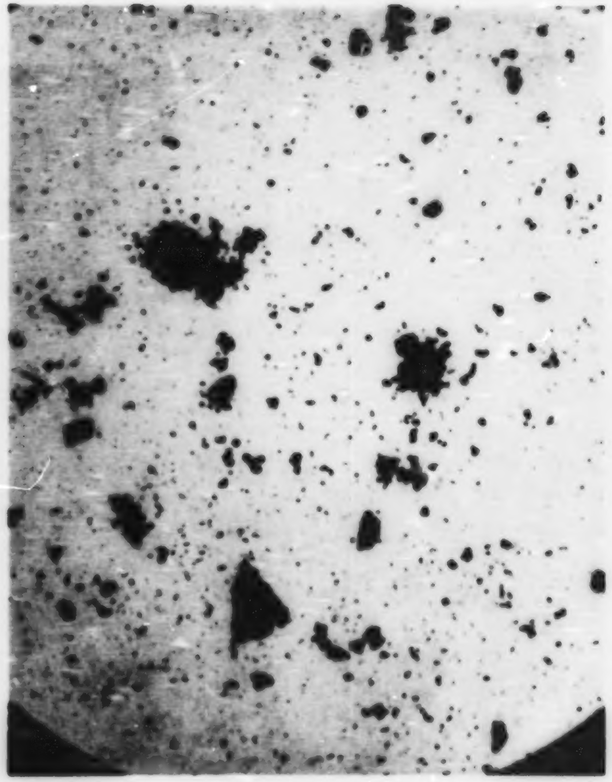

Figure 9

Figure 10

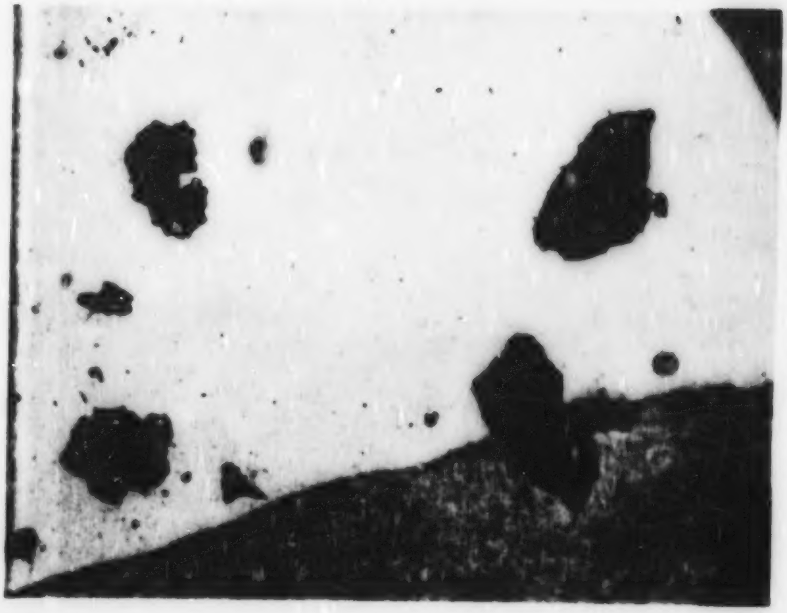

Figure 11

Figure 12

Figure 14

Figure 13

Figure 15

APPENDIX I

EPA REPORT OF CONTINUOUS OPACITY MEASUREMENTS USING A TRANSMISSOMETER

Great Lakes Carbon Corporation
St. Louis, Missouri
April 21-24, 1975

CONTINUOUS OPACITY MEASUREMENTS OF
COKE-SIDE EMISSIONS USING A TRANSMISSOMETER

(Supplemental report to EPA Contract Report No. 68-02-1408,
Task No. 14; Study of Coke-Side Coke Oven Emissions)

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CONTINUOUS OPACITY MEASUREMENTS OF COKE-SIDE EMISSIONS USING A TRANSMISSOMETER

INTRODUCTION

As part of an EPA study of coke-side oven emissions at a coke manufacturing plant of the Great Lakes Carbon Corporation (GLC), St. Louis, Missouri, a transmissometer was temporarily mounted in the fan exhaust system leading from the coke-side shed. The transmissometer system was used to continuously measure the transmittance (or optical density) of the exhaust air discharged from the emission entrapment structure during the time manual sampling for particulate-mass concentration was being conducted by an EPA contractor.[a] The purpose of the transmissometer measurements was to monitor the opacity of the rapidly fluctuating particulate loadings released during the coke-push cycle in an attempt to determine the relative contribution of the coke-push period to the overall coke-side emissions. The real-time data also provide an indication of the effectiveness of the ventilation system in removing the entrapped emissions from the shed. Other applications of the transmissometer data, such as characterization of the process operation, became apparent as the study progressed.

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[a] Background information describing the scope of the EPA study and the physical features of the coke-side shed entrapment structure are presented in the Contractor Report No. 68-02-1408, Task 14: "Study of Coke-Side Coke Oven Emissions," prepared by Clayton Environmental consultants for the Division of Stationary Source Enforcement.

DESCRIPTION OF TRANSMISSOMETER SYSTEM AND ITS OPERATION

A Lear-Siegler RM-4 Optical Transmissometer was used to continuously monitor the smoke density levels in the exhaust duct of the shed. The RM-4 transmissometer is an electro-optical instrument that measures the attenuation of a light beam transmitted, in this application, through the exhaust airstream. The beam is transmitted across the exhaust duct to a retroreflector, which reflects the beam back across the stack to a detector. Because the instrument utilizes the visible light spectrum, the opacity readings can be related to opacities sensed by the human eye.

The RM-4 model transmissometer is designed for data output in units of either optical density or opacity.[a] To facilitate correlation of the transmissometer measurements with the particulate concentrations in the exhaust duct, a linear optical density readout scale was selected. The density measurements were continuously recorded on a strip chart recorder. The analog strip chart records were manually reduced and translated into optical density values by a data reduction technique described later in this report.

The transmissometer system was mounted on the exhaust duct near the point of exit from the shed structure, approximately 20 feet upstream of the exhaust fan and 60 feet from the manual particulate sampling site. (See Figure 1). The transceiver and retroreflector were mounted horizontally to 4-inch flanges located approximately 29 inches from the bottom of the 6-foot-square duct.

Transmissometer measurements were made continuously during the 4-day period of particulate emissions tests

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[a] The optical density and opacity relationship is defined as follows:

$$\% \text{ transmittance} = 100 - \% \text{ opacity}$$

$$\text{Optical density} = \text{Log}_{10} \frac{100}{\% \text{ transmittance}}$$

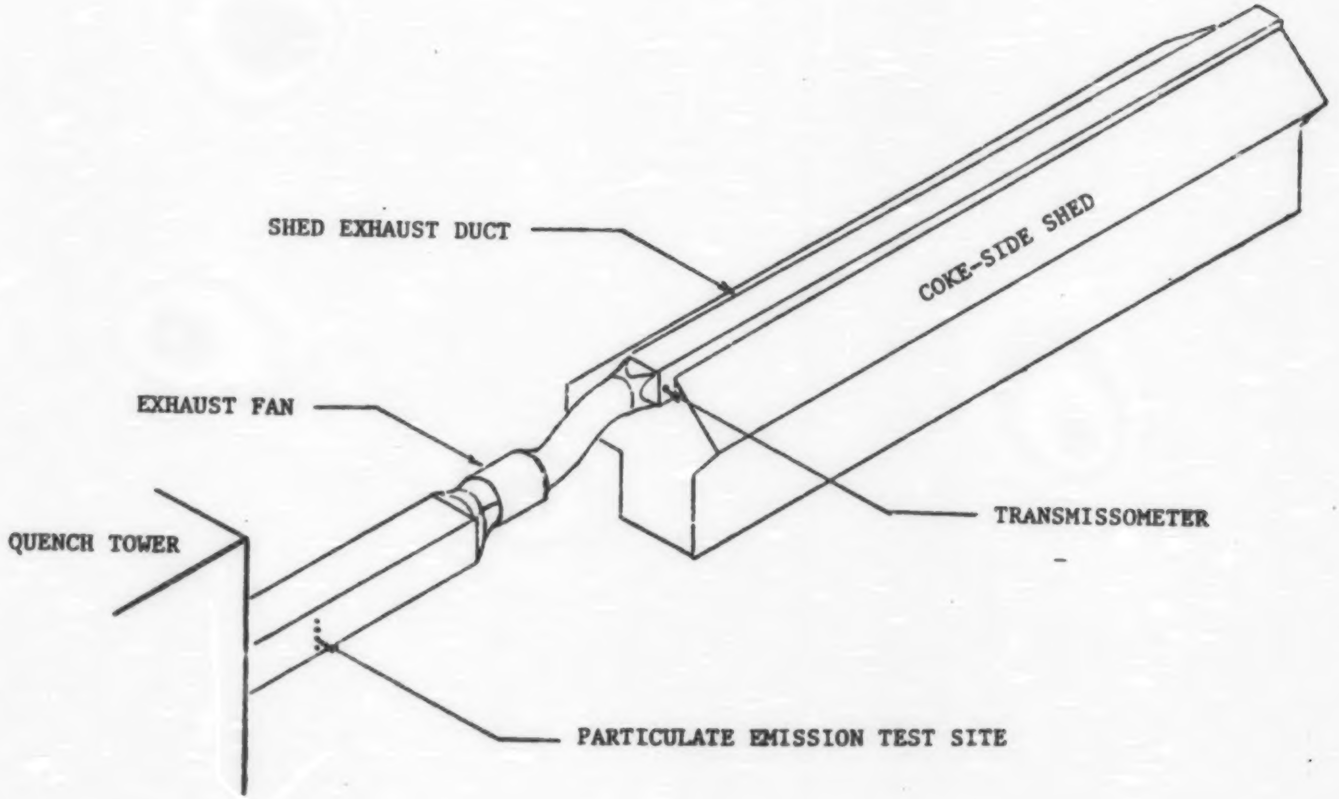

Figure 1. Location of transmissometer system temporarily installed at the GLC Plant.

(April 21-24, 1975). During the night-time non-testing hours (1800-0800), the strip chart recorder was operated on low chart speed (2 inches/hour) to minimize the generation of strip chart paper. During the daytime while particulate sampling was in progress, higher chart speeds (2 to 4 inches/minute) were used to allow better peak resolution and more accurate delineation of the relatively short-term "bursts" of coke-push emissions. After initial operation of the instrument on the 0 to 0.45 optical density (OD) full-scale range (about 65 percent opacity) during the earlier tests, the unit was switched to the highest range, 0 to 0.9 OD, when measurements indicated that the peak opacity during pushes of "green" coke[a] often exceeded 60 to 80 percent. Sensitivity in detecting the very low optical density values measured between coke pushes possibly could have been increased by operating on the lower span ranges; however, the instrument appeared to provide adequate sensitivity even at the very low end of the 0.9 OD scale.

The transmissometer zero and span calibrations were checked at least twice daily. Little or no calibration drift was noted over 7 days of operation, even though strong vibrations were induced in the duct structure by the operation of a large-diameter axial fan some 20 feet downstream. No instrument malfunctions or other operating problems occurred during the test period.

TIME/DENSITY PATTERNS OF COKE-SIDE EMISSIONS

The highly cyclic nature of the coke-side emissions is apparent in the transmissometer recorder tracing shown in Figure 2. This low-speed strip chart tracing depicts the

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[a] "Green" coke is insufficiently carburized coke containing quantities of volatile carbonaceous materials that ignite and burn when exposed to the atmosphere.

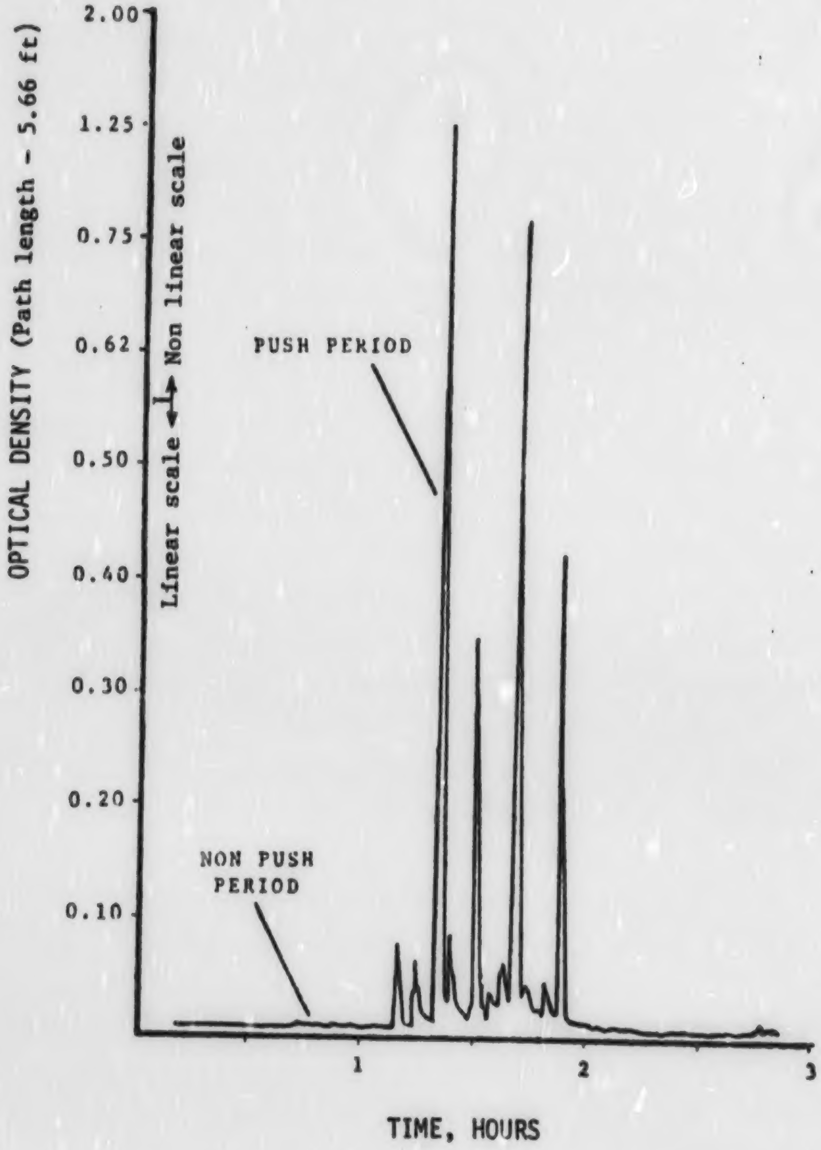

Figure 2. Tracing of optical density/time variations of coke-side particulate emissions from coke oven battery.

time intervals of one complete push turn on the coke-oven battery equipped with the coke-side shed. A push turn for a battery at the GLC plant normally consists of pushing five to six ovens in sequence at 15- to 20-minute intervals; the corresponding prominent peaks, varying in magnitude, are shown clearly in the tracing. These peaks represent the emissions generated during a coke push of less than 1 minute duration. The higher-than-baseline density levelsoccurring between pushes are contributed by various other coke-side operations connected with the pushing event, such as oven-door removal, door-jamb cleaning, and clearing of coke debris from the bench following the push. The relatively constant but low level of density preceding and following the 1- to 1 1/2-hour push turn represents background coke-side emissions contributed mainly by leaking oven doors.

Composite tracings of individual coke-push events recorded at the higher chart speeds used during daytime particulate emissions testing are shown in Figure 3. The tracings are of actual push events, selected to typify subjective ratings of the "greenness" of the coke being pushed or, loosely, the "greenness" of the push. The tracings show that the total time from start of a push to complete evacuation of the smoke emissions captured by the coke-side shed was usually about 1 1/2 to 2 minutes. The rapid decrease in optical density levels after the push and the relatively consistent length of time required to clear smoke from the shed indicate that the fan system is adequately designed and sized for efficient removal of entrapped particulate from the shed even in pushes of very green coke. The emission profiles shown in Figure 3 are a fair representation of changes in particulate concentrations

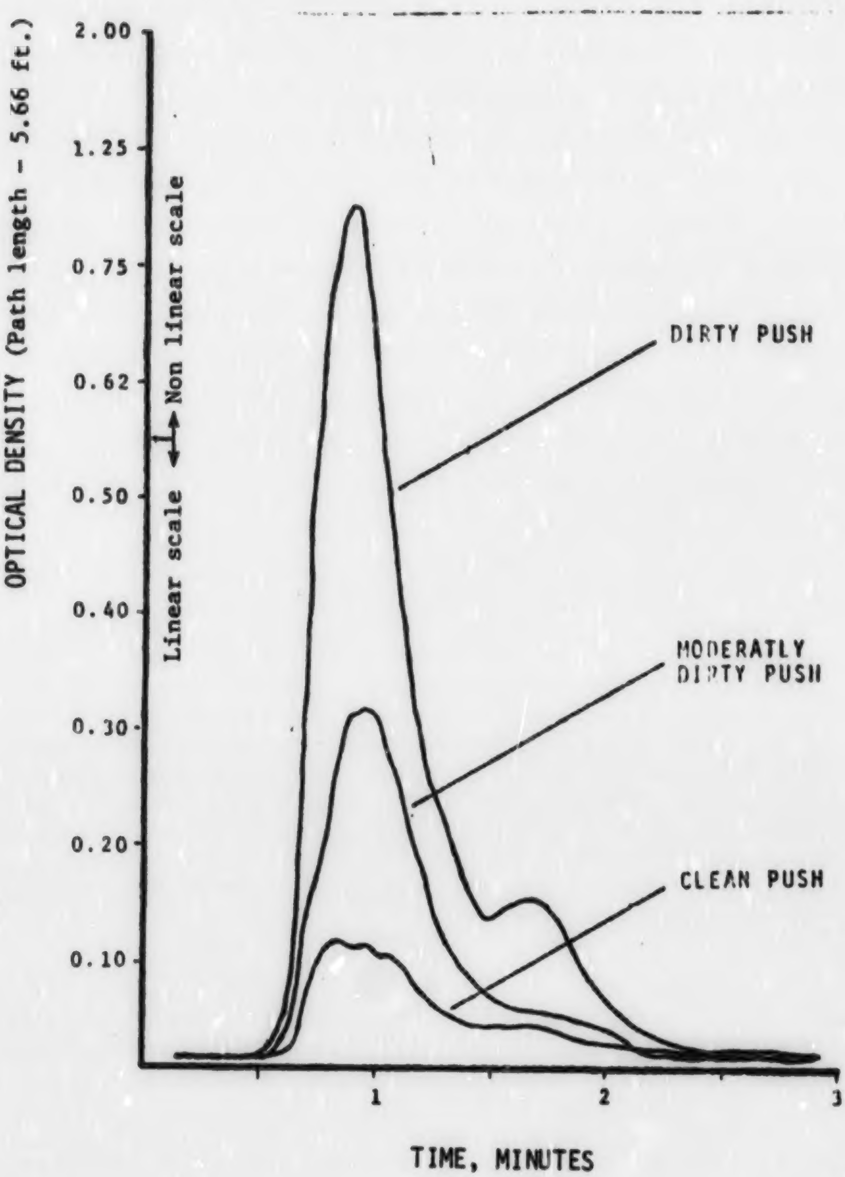

Figure 3. Composite tracing of optical density time variations of coke-side particulate emissions for typical coke pushes.

during coke pushes at this plant. All of the pushes monitored during the EPA study exhibited a similar time/density pattern, which follows closely the thermal expansion (volume) curve predicted by designers of the shed.[a]

Detailed variations of particulate loadings in the shed exhaust were correlated with the push operation sequence during several pushes. Figure 4 shows an individual tracing with the time scale indexed according to the push operation taking place. The emission profiles of this push and the other examples shown in Figure 3 are generally consistent with what would be predicted by persons familiar with the physical features and operation of a coke-oven battery. Suggested explanations for each segment of the curve are as follows:

A. At the start of the push (Point 1), particulate emissions rapidly increase to a maximum value (Point 2). Generally, the ends of the coke mass, which tend to be less fully coked because of heat loss through the oven doors, contribute most of the emissions. EPA's visual observation and rating of coke pushes at this plant suggest that the coke-side end accounted for more than two thirds of the greener-than-average pushes.[b] At other plants the push-side end may be an equal or more significant factor in the pushing of green coke, depending on the battery maintenance or other physical features.

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[a] Reference is made to the bell-shaped curve shown in Drawing No. 3 contained in U.S. Patent No. 3,844,901 dated October 29, 1974 for coke oven emission control system assigned to Great Lakes Carbon Corporation, N.Y., N.Y.

[b] A tabulation of optical density values and push ratings for 50 pushes is presented in Table A-1. The three-digit push rating was designed to reflect of the greenness of the three parts of the push, end-middle-end, as well as the intensity of emissions. Ratings are on a scale of 1 to 4.

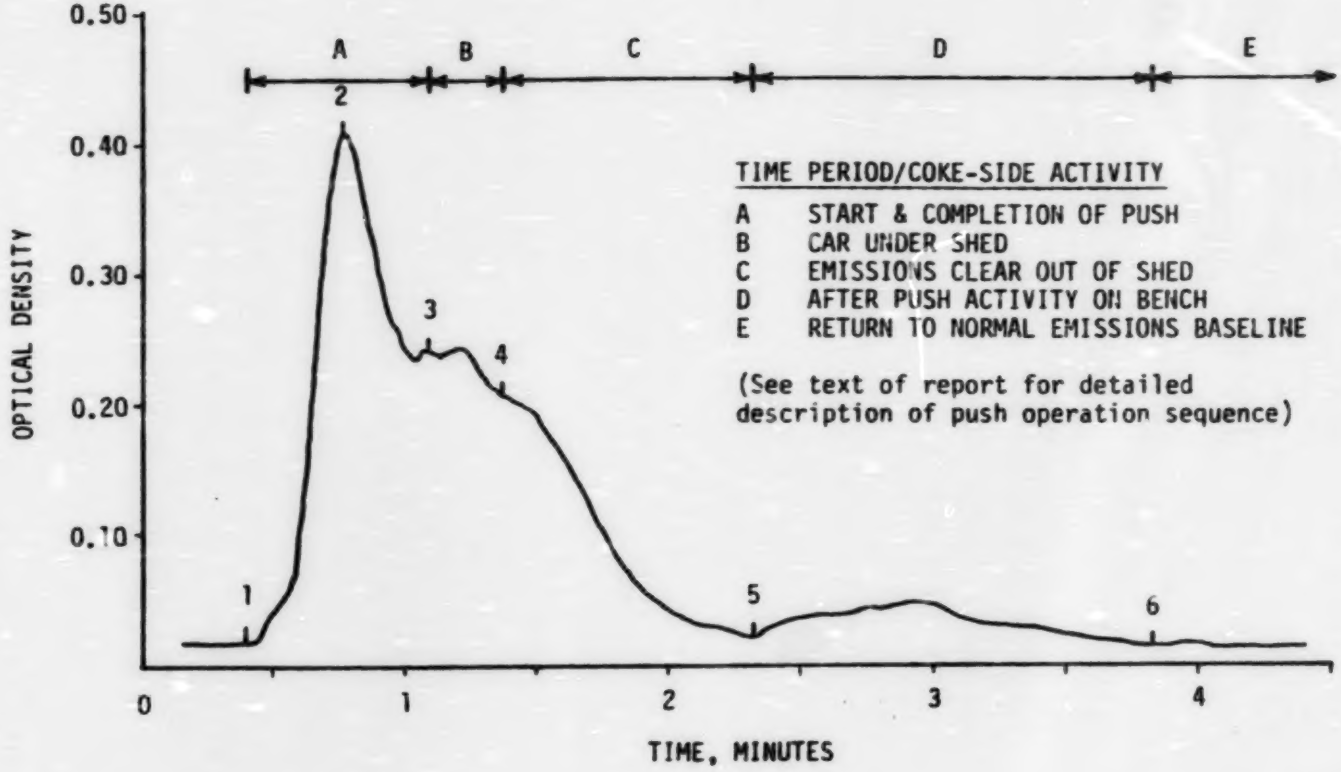

Figure 4. Correlation of coke-side particulate emissions with push operational events.

B. The optical density levels begin to decrease fairly rapidly from the initial peak (Point 2). Relatively fewer emissions are generated while the better-coked middle section of the coke mass is emerging from the oven. Particulate emissions are being evacuated from the shed at a faster rate than emissions are being generated.

C. As the push-side coke end emerges from the oven and is exposed to the atmosphere, another burst of emissions results, creating a second, smaller peak (Point 3). The push-side coke end generally is less coked than the middle section but more coked than the coke-side end at this plant.

D. The oven is clear of coke and the quench car has transported the hot coke from under the shed structure (Point 4). Emissions continue to decrease as the remaining entrapped smoke and dust are cleared from the shed by the ventilation flow.

E. Cleanup operations on the bench immediately after the push (Point 5) may generate sufficient emissions to keep the baseline slightly elevated for another 1 to 2 minutes. These activities include shoveling burning coke debris from the bench, cleaning door jambs, and other routine operations before the oven door is placed back on the oven and luted.

F. Eventually the particulate level in the shed returns to baseline conditions (Point 6). The aggregate emissions contributed by the manifold, but relatively small, oven leaks tend to maintain a fairly constant, low-level background of dust and smoke in the shed exhaust at all times.

TRANSMISSOMETER DATA REDUCTION

The transmissometer measurements made during the push-cycle emission test periods were reduced to units of average and peak optical density for comparison and correlation with the particulate-mass concentration measurements. The average optical density was determined graphically from the transmissometer strip charts by manually integrating the area under the chart tracing for the measured time period.

Copies of the strip chart recordings made during the 1-week study period are included in Appendix B. A calibration curve for scaling and reducing the chart readings to optical density units is shown in Figure A-1. The calibration curve was developed by experimental measurement of known optical density filter standards[a] in an EPA laboratory prior to installation of the instrument at the GLC plant. The technique used to reduce the chart readings is illustrated in Figure A-2, which shows the grid superimposed over the chart tracing. Essentially, the average smoke density, translated into optical density units (OD), is multiplied by the measurement interval, expressed in seconds, to give a value expressed in optical density-seconds (OD-Sec). The OD-Sec value is closely related to particulate-mass flowrate, discussed in the following section. A complete tabulation of optical density data reduced from the strip chart recordings in this fashion appears in Tables A-3 through A-7.

The transmissometer data obtained during particulate emission tests are summarized in Table 1 along with pertinent data on the particulate concentrations determined concurrently.[b] The average optical density calculated for each of the four test periods is shown on line 9; the average grain loading for each of the tests is shown on line 20. The values show that correlation between the optical density measurements and grain loadings for each of the test periods

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[a] Following the procedure outlined in EPA Emission Monitoring Requirements, Appendix B - Performance Specifications, paragraph 8.1 - Transmissometer Calibration, published in Federal Register dated October 6, 1975.

[b] Results of sampling are presented in the contract report cited earlier (No. 68-02-1408, Task 14).

Table 1. SUMMARY OF TRANSMISSOMETER DATA COLLECTED DURING PUSH-CYCLE EMISSION TESTS

Test number (1)		1	2	3	4
Date of test (2)		4/21-22	4/22	4/23	4/24
Number of pushes sampled (3)		16	11	10	5
Sampling time, sec	Total period (4)	17,280	11,520	11,820	7,500
	Push mode (5)	1,730	1,175	1,100	575
	% total (6)	10.01	10.20	9.31	7.66
	Nonpush mode (7)	15,550	10,345	10,720	6,925
	% total (8)	88.99	89.80	90.69	92.33
Optical density (1.73 meter path)	Avg. for period (9)	0.01659	0.01417	0.01225	0.02561
	Avg. push mode (10)	0.10877	0.09544	0.06772	0.22454
	Avg. nonpush (11)	0.00634	0.00494	0.00655	0.00909
	Max. push peak (12)	1.2500	0.7500	0.5100	2.000
	Min. push peak (13)	0.0700	0.0550	0.0750	0.108
Optical density, seconds	Total for period (14)	286.76	163.20	144.79	192.08
	Push mode (15)	188.18	112.15	74.50	129.11
	% total (16)	65.62	68.72	51.45	67.22
	Nonpush mode (17)	98.58	51.05	70.29	62.97
	% total (18)	34.38	31.28	48.55	32.78
	Avg. push value (19)	11.76	10.19	7.45	25.82
Particulate concentration	Grains/acf (20)	0.018	0.013	0.014	0.026
	Grams/Am^3 (21)	0.0417	0.0295	0.0329	0.0597
Emission rate	lbs/hr (22)	20.6	13.7	15.7	29.0
Ratio: Avg. OD to grains/acf (23)		0.921	1.090	0.875	0.985

was reasonably good. In fact, the ratio of optical density to grain loading for each test run, reported on line 23, is approximately 1:1, and variations did not exceed 20 percent in any test. Although the two sets of data from Test No. 3 did not agree as closely as the data sets from the other tests, the deviation is within the acceptable range of measurement error for the two sampling techniques. The utility of continuous opacity measurements in estimating particulate loadings during push periods and other short-term process events depends on a strong correlation between the optical density and mass concentration measurements.

CORRELATION OF TRANSMISSOMETER MEASUREMENTS WITH PARTICULATE LOADING

The data in Table 1 demonstrate a good functional relationship between the transmissometer measurements and particulate loadings. Although the data are limited to four tests, the transmissometer can be empirically calibrated in terms of particulate concentrations. The relationship between optical density and particulate-mass concentrations for coke-side emissions during the emission test period is shown in Figure 5, in which the average optical density readings for each of the emission tests are plotted against the measured particulate concentrations. A straight-line calibration curve is drawn through the data points by use of least-squares linear regression analysis. The four data points designated 1A through 4A represent average particulate concentrations and optical densities measured during each of the push-cycle emission tests. The three data points labeled 1B through 3B, plotted in the lower left of the chart, represent particulate concentrations measured during the nonpush cycles.

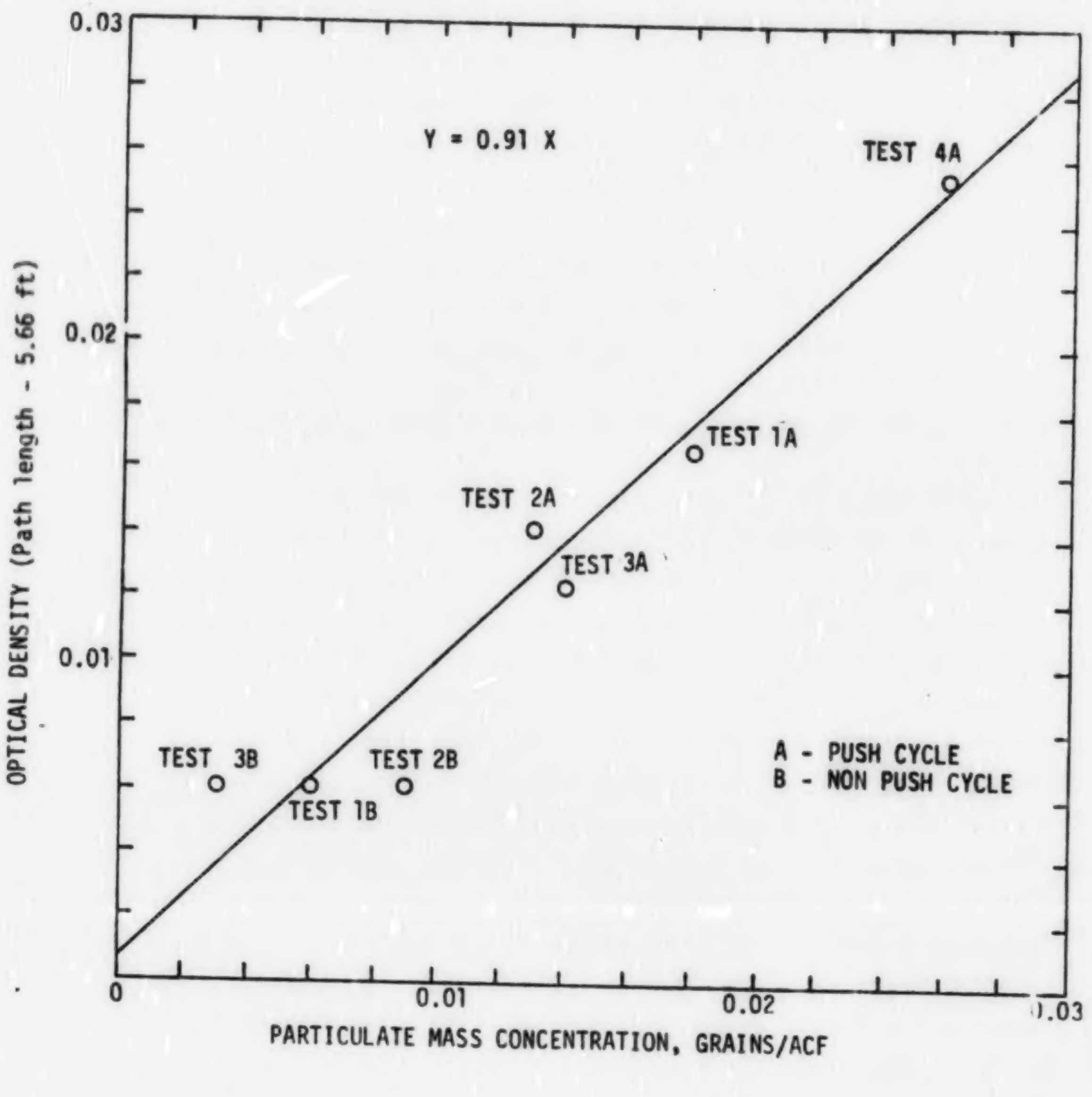

Figure 5. Optical density-mass concentration relationship of coke-side particulate emissions.

The average optical densities for the nonpush cycles were estimated differently than those for the push cycles. Strip chart records show that when the ovens were not being pushed, optical densities measured in the exhaust duct were consistently very low. The nonpush OD readings seldom rose above background levels except when oven leaks became unusually severe or persistent. Most of the time the optical densities ranged from 0.004 to 0.008. The OD measurements reported in Table 1 for the nonpush mode (time between pushes during push-cycle test) support this observation. The average OD reading between pushes for the four test periods was approximately 0.007. Therefore, rather than attempting to manually integrate the minuscule area under the strip chart tracing for the nonpush cycle, an average OD reading of 0.006 was arbitrarily selected to represent the background OD value for all three nonpush-cycle emission tests.

The rationale for assuming a constant baseline value for nonpush conditions is as follows. First, the error associated with visually scaling these low chart values would negate any increased accuracy gained by accounting for the occasional excursion from baseline values. Second, a certain amount of inaccuracy is unavoidable in reading the extremely low-level background chart traces. With an in situ instrument (across-the-stack measurement) there is no way of establishing "absolute" zero on the transmissometer readout scale while the device is mounted on the exhaust duct. As the fan system moves contaminated air from the shed, the airstream contains some smoke and dust at all times. Shutting down the fan will not provide a clean optical path since dust-laden air can continue to infiltrate the open duct system. An alternative calibration procedure is to set up the transmissometer system in the laboratory to simulate the actual field pathlength conditions and make the necessary zero and span calibration adjustments on clean room air before installing the unit on the exhaust duct. After the unit is placed on the exhaust duct, the electronic zero adjustment control is used to establish the zero point during the period of emission testing. With this technique of setting the zero point on the transmissometer scale in the field, the low-level baseline optical density values could not be measured much closer than 0.002 OD unit. The sensitivity of the transmissometer is adequate to detect changes of 0.001 OD or less in the smoke density levels but inaccuracies entailed in setting true zero preclude highly accurate readings when the optical density is near the zero end of the measurement range.

The straight-line correlation curve shown in Figure 5 can be expressed in equation form:

$$y = 0.91x$$

where: y = optical density
x = grains/acf

This equation can be used to convert the instantaneous optical density readings recorded at the GLC plant to equivalent grain loadings. Thus, the transmissometer, with its fast temporal resolution, when properly calibrated in terms of particulate mass concentrations, can provide at least a semiquantitative estimate of the short-term peak particulate loadings. Of course, the equation is applicable only for converting the optical density readings made at the GLC plant and under the same optical path length (1.73 meters). For application of the data to other coke-manufacturing plants and other path lengths, it is useful to convert the optical density scale to an attenuation coefficient (extinction per unit path length) for coke-side particulate emissions. The equation for the conversion is as follows:

$$\sigma = \frac{2.303\ (OD)}{L}$$

where: σ = attenuation coefficient (meter^{-1})

OD = measured optical density

L = path length in meters

The opacity-mass relationship shown in Figure 5 is replotted in Figure 6 in terms of the attenuation coefficient and mass-concentration expressed in metric units. If the path length (diameter or width of the duct or stack) of any given outlet stack is known and either the opacity or the mass-concentration of particulate emissions is known, the other parameter may be estimated by use of the slope (K) of the curve in Figure 6 and the following equation:[a]

$$\%\ \text{opacity} = (1-e^{-KC_mL}) \times 100$$

where: $K = \frac{\text{attenuation}}{\text{mass concentration}}$ [meter^2/gram]

Cm = mass concentration [gram/meter^3]

L = path length of opacity measurements [meters]

As an example of the application of this equation and the K factor for coke-side emissions (0.53), one could estimate the maximum grain loading not to exceed 20 percent opacity when emissions are vented from the shed capture device into the atmosphere through a 6-foot stack.

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[a] Formula derived by William D. Conner, National Environmental Research Center/RTP, author of EPA publication No. AP-30, Optical Properties and Visual Effects of Smoke-Stack Plumes, revised May 1972.

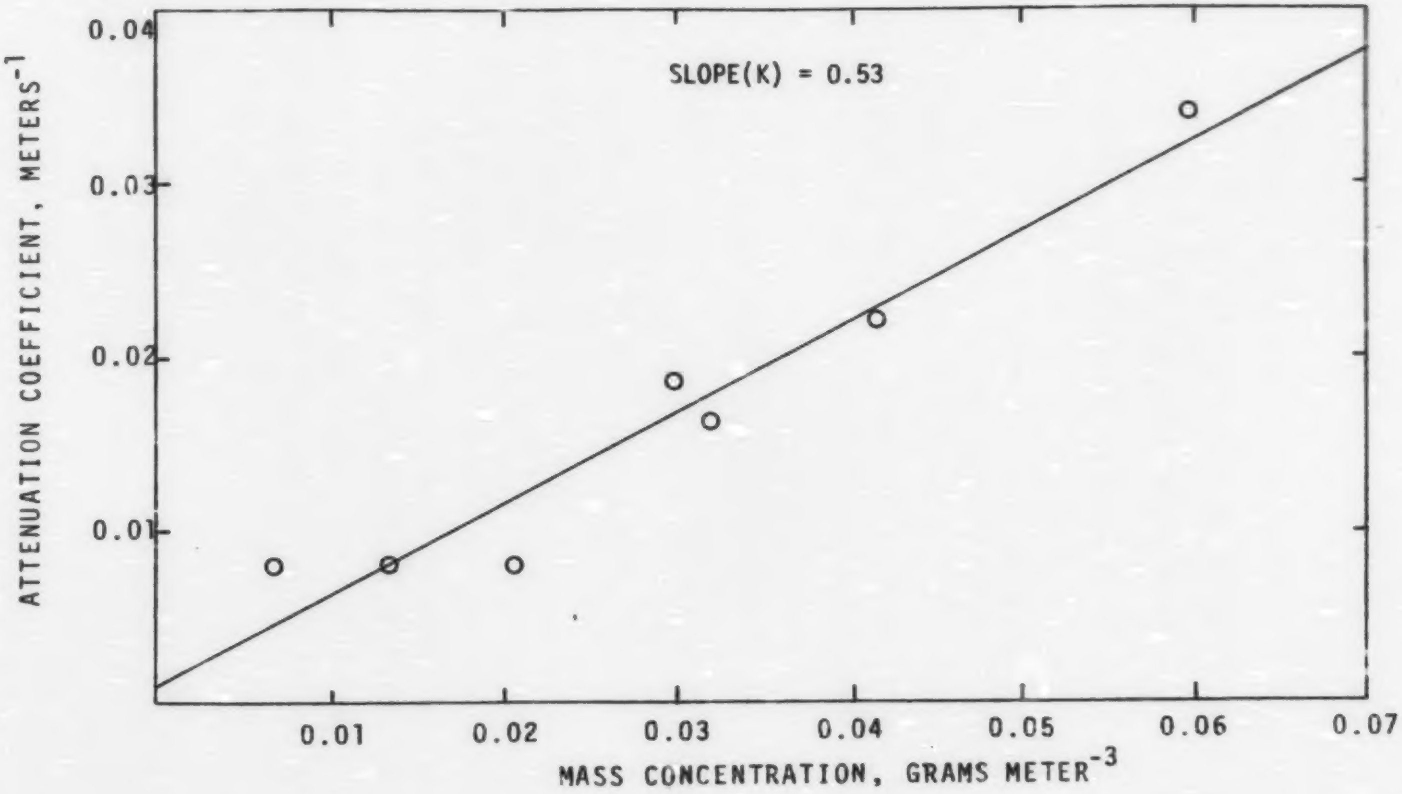

Figure 6. Opacity-mass concentration relationship of coke-side emissions.

$$C_m = \frac{\ln - \frac{\%Op}{100} - 1}{(K)(L)}$$

$$C_m = \frac{\ln \quad (0.8)}{(0.53)\ (1.83)}$$

$$C_m = \frac{0.223}{0.970} \sim 0.23 \text{ grain/acf}$$

CONTRIBUTION OF PEAK EMISSIONS TO TOTAL PUSH-CYCLE EMISSIONS

As stated earlier, the OD-Sec data reported in Table 1 for each of the push-cycle tests were derived by multiplying the average optical density by the time interval in seconds and summarizing these values for the entire test period. Thus, the OD-Sec parameter reflects concentration as well as the duration of the particulate loading and, therefore, is an indirect measure of pollutant mass flowrate. In reduction of the strip charts, individual OD-Sec data reported in Table 1 for the "push mode" represent emissions from the time the push is started until approximately 1 to 1 1/2 minutes later, when the particulate in the exhaust duct has returned to near-background levels. The data for the "nonpush mode" reflect densities measured at all other times during the push-cycle test period.

Comparison of data from the push mode and the nonpush mode reveals that, on the average, 63 percent of the total push-cycle emissions are released during the peak push period. Particulate emissions emitted during other phases of the push-cycle operation, include background emissions from oven-door leaks, contribute the remaining 37 percent. This estimate of the relative contribution of the peak push period (63 percent) agrees well with the estimate of 56 percent, determined independently from the manual particulate sampling data.[a]

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[a] Given in the contract report referenced earlier.

REPRESENTATIVENESS OF PUSH-CYCLE TEST RESULTS

The continuous transmissometer measurements provided a record of the GLC plant operation for the entire 4-day emission testing period and also for 2 weekend days preceding the test. Visual examination of the strip chart tracings and review of the optical density data reveal no identifiable periods in which plant operation differed substantially from what plant management reports to be normal and typical of the present operating practices. It is noted, however, that in the push-cycle emission test conducted on April 24th (Test No. 4), a combination of short sampling period and one or more extremely green pushes during that period may have markedly influenced the data for that test.

The grain loading reported for Test No. 4 in Table 1 is approximately twice the grain loadings reported for the other three push-cycle tests. Examination of the transmissometer data revealed that at least one of the coke pushes in the Test No. 4 sampling period (Oven No. 53), was unusually green, generating particulate emissions approximately 10 times greater than those released from a typical push at the GLC plant. In Figure 7, the chart tracing of this push is superimposed over the typical push tracings as given in Figure 3 to illustrate the greater magnitude of emissions caused by this push. Although the push must be considered atypical of normal operations at the GLC plant, its effect on emissions gives some idea of the high level of coke-side particulate emissions that can occur under worst-case conditions. The high particulate loading of this single push, when averaged with those from the relatively few pushes sampled during this test, definitely biased the average grain loading for the entire test period.

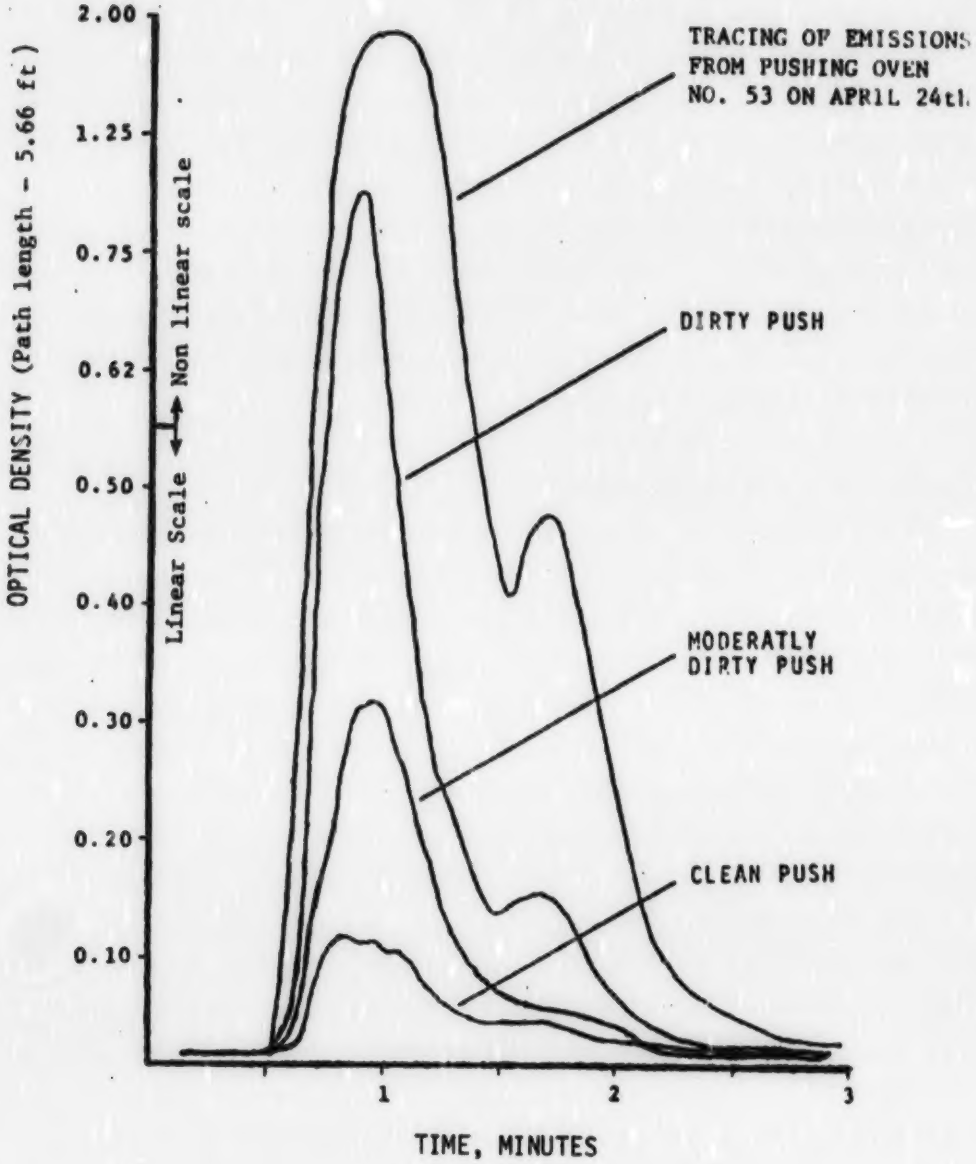

Figure 7. Comparison of push emissions from an excessively green push with typical pushes.

The higher grain loading for Test No. 4 can be "adjusted" by substituting the OD-Sec value of a typical push for the value recorded in the extremely green push, and recalculating the average optical density. Substituting the median push value[a] of 6.5 OD-Sec for the value of 73.3 OD-Sec recorded in the green push gives an "adjusted" average optical density of 0.016 for test period No. 4. Applying the conversion factor[b] to the adjusted average optical density of 0.016 gives an equivalent grain loading of about 0.0167 grain/acf. Therefore a more realistic range of grain loadings for a typical push cycle at the GLC plant would be 0.013 to 0.018 grain/acf, with an average push-cycle emission rate of about 17 pounds per hour.

VARIABILITY OF PUSH EMISSIONS

The maximum and minimum optical densities recorded for peak push periods during the four push-cycle tests are included in Table 1. The peak emission intensities ranged from a low of 0.07 to a high of 2.0 OD; these values indicate a range of some 30-fold for about 40 push events included in the push-cycle sampling. This wide range of optical densities, together with the chart tracings of individual pushes shown in Figure 3, illustrates the high variability of emissions among individual push events.

Optical density readings for all of the push tracings graphically reduced from the strip chart recordings are listed in Table A-1. The push events were ranked by peak optical density readings and a bar chart constructed (Figure 8) to show the relative frequency of occurrence. The pushes are grouped into 12 classes of peak optical density ranging from 0 to 1.2 and four classes of opacity ranging from

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[a] Median OD-Sec value for pushes is shown in Figure 9.

[b] grain/acf = $\frac{OD}{0.91}$

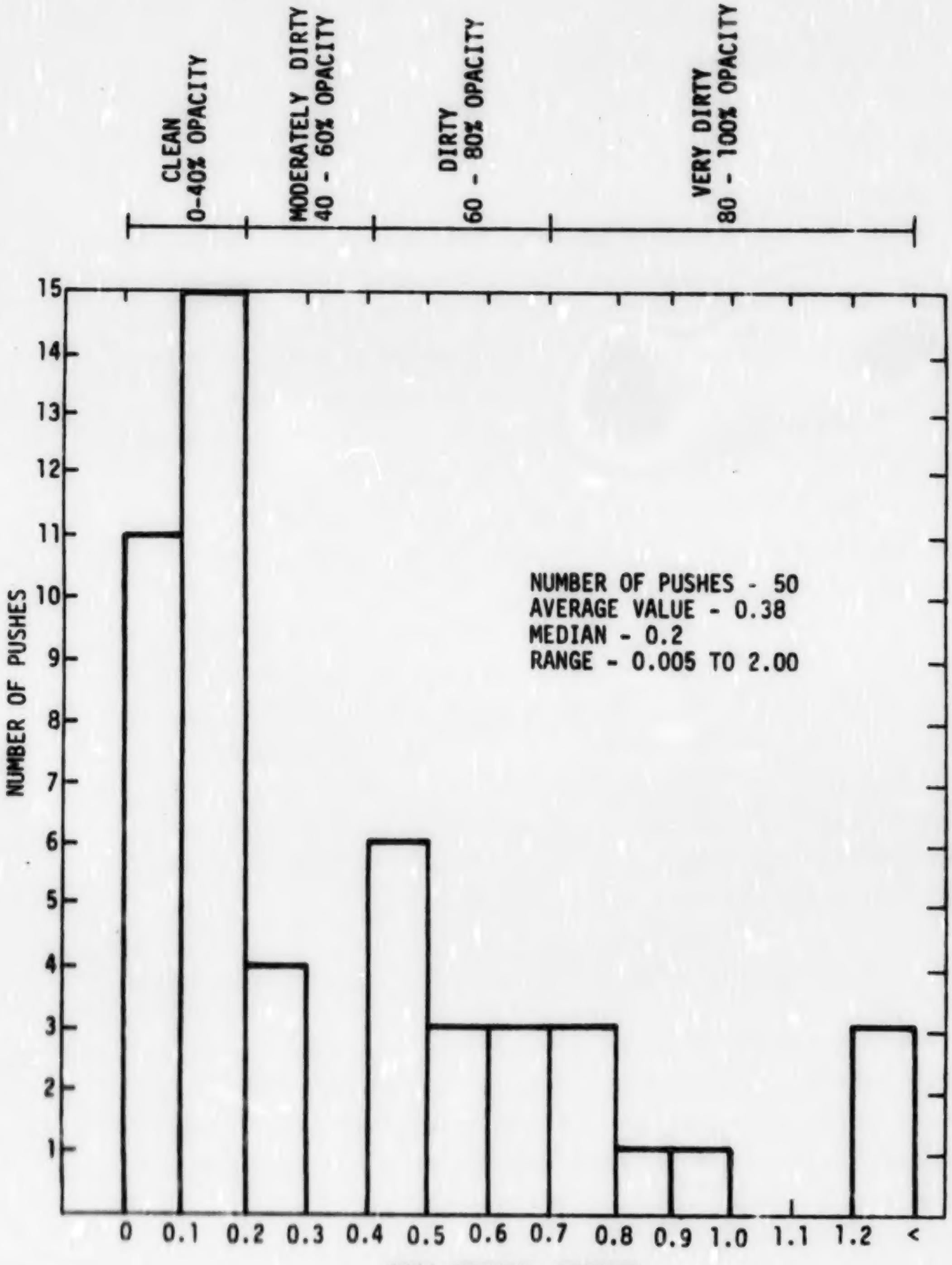

Figure 8. Frequency distribution of peak optical density readings of coke pushes.

"clean" to "very dirty" on a scale of 0 to 100 percent. As the chart shows, over half of the pushes monitored at the CLG plant during the 1-week test period are classified as "clean," not exceeding 0.2 OD (40 percent opacity). On the other hand, at least 16 percent of the pushes are rated as "very dirty" (greater than 0.7 OD and 80 percent opacity). This finding suggests that even in a well-operated coke plant, occasional pushes yielding heavy emissions are unavoidable.

The OD-Sec values calculated for individual pushes are tabulated and ranked in Table A-2 in the same manner as the peak optical density measurements. A bar chart of the frequency distribution of the OD-Sec values is shown in Figure 9. This chart indicates that most of the pushes contributed only nominally to the overall coke-side emissions. As the pushes become increasingly green, however, the total mass emissions released during the push increases dramatically. As in the range of peak OD readings, emissions contributed by the very dirty pushes are at least 30 times those of the very clean pushes.

RELATIONSHIP OF PEAK OPTICAL DENSITY TO PARTICULATE MASS EMISSIONS

As described earlier, the typical pattern for a push period (shown in Figure 3) consists of a sharp increase in optical density, reaching a maximum soon after the start of the push, followed by a less rapid decline to background levels within about 1 1/2 minutes from the start of the push.

An attempt was made to correlate the height of the peak (OD) with the area under the tracing recorded on the strip chart (OD-Sec). The peak height represents maximum optical

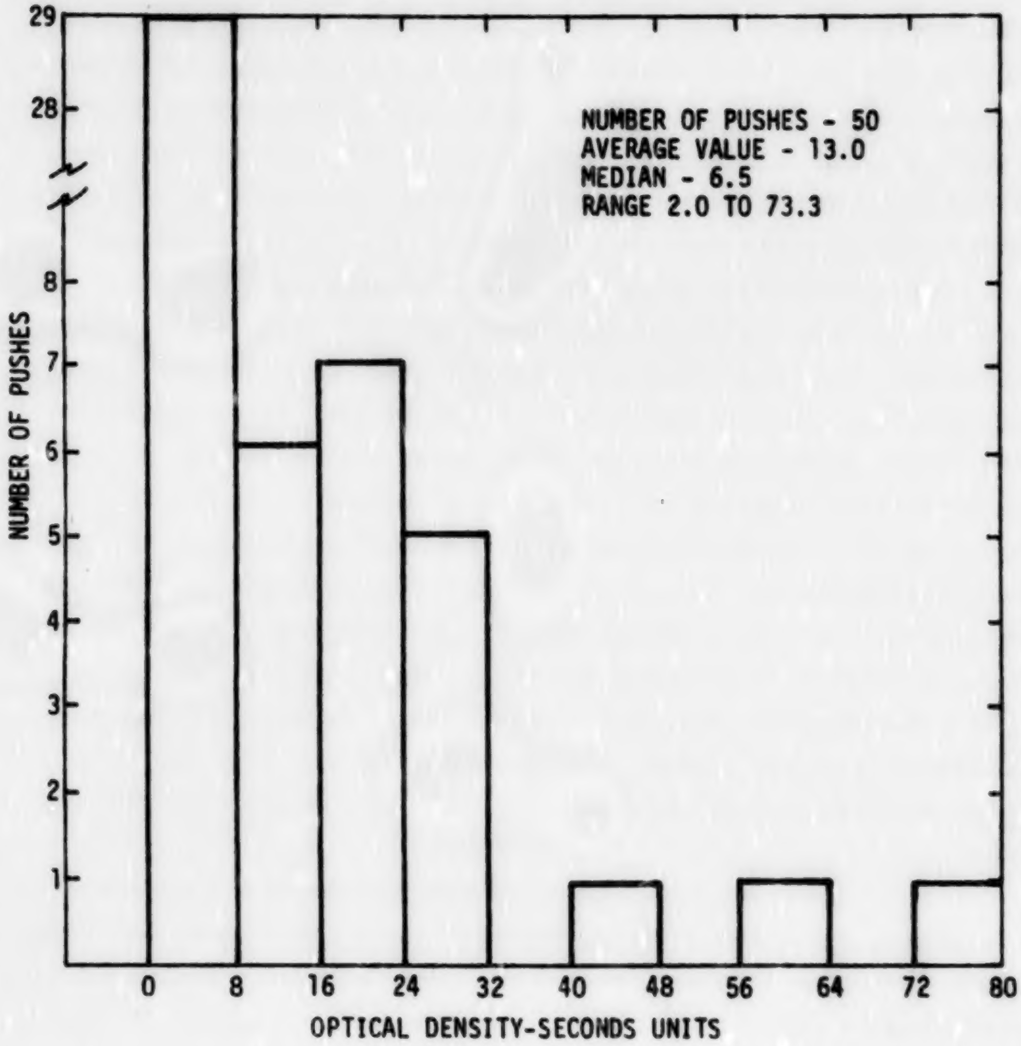

Figure 9. Frequency distribution of OD-Sec values recorded for coke pushes.

density or mass concentration and the peak area is analogous to pollutant mass flow rate. The maximum optical density reading for each push is plotted against the OD-Sec value calculated for that push, yielding a correlation as shown in Figure 10. Since the data points show a reasonably linear relationship, one may assume that the maximum optical density value for a given push is a good indicator of the total emissions contributed by the push.

This correlation can be used to advantage to simplify the strip chart data reduction method for estimating push emissions and the visual technique used to rate greenness of the pushes. For example, an easier method of quantifying the mass emissions of each push might be to scale only the peak optical density off the transmissometer strip chart tracing or a nonrecording meter readout device and apply the conversion factor shown in Figure 10 to calculate the total OD-Sec value. This procedure eliminates the tedious manual integration of the strip chart tracing for each push. Also, the relationship provides a rationale for simplifying the subjective visual technique used during the EPA study to rate opacities and thus the degree of greenness of the coke pushed.

The technique used to rate the opaqueness of plumes resulting from the pushing of each coke oven is as follows. Each push was divided into three approximately equal parts: coke-side end, middle, and push-side end. Plumes emitted during each of these parts were then rated in terms of opacity on a scale ranging from 1 to 4, clean to dirty. A faint or light plume was rated 1, and an especially dense plume, usually accompanied by flames, was classified as 4. The sum of the three digits rated for each part of the push

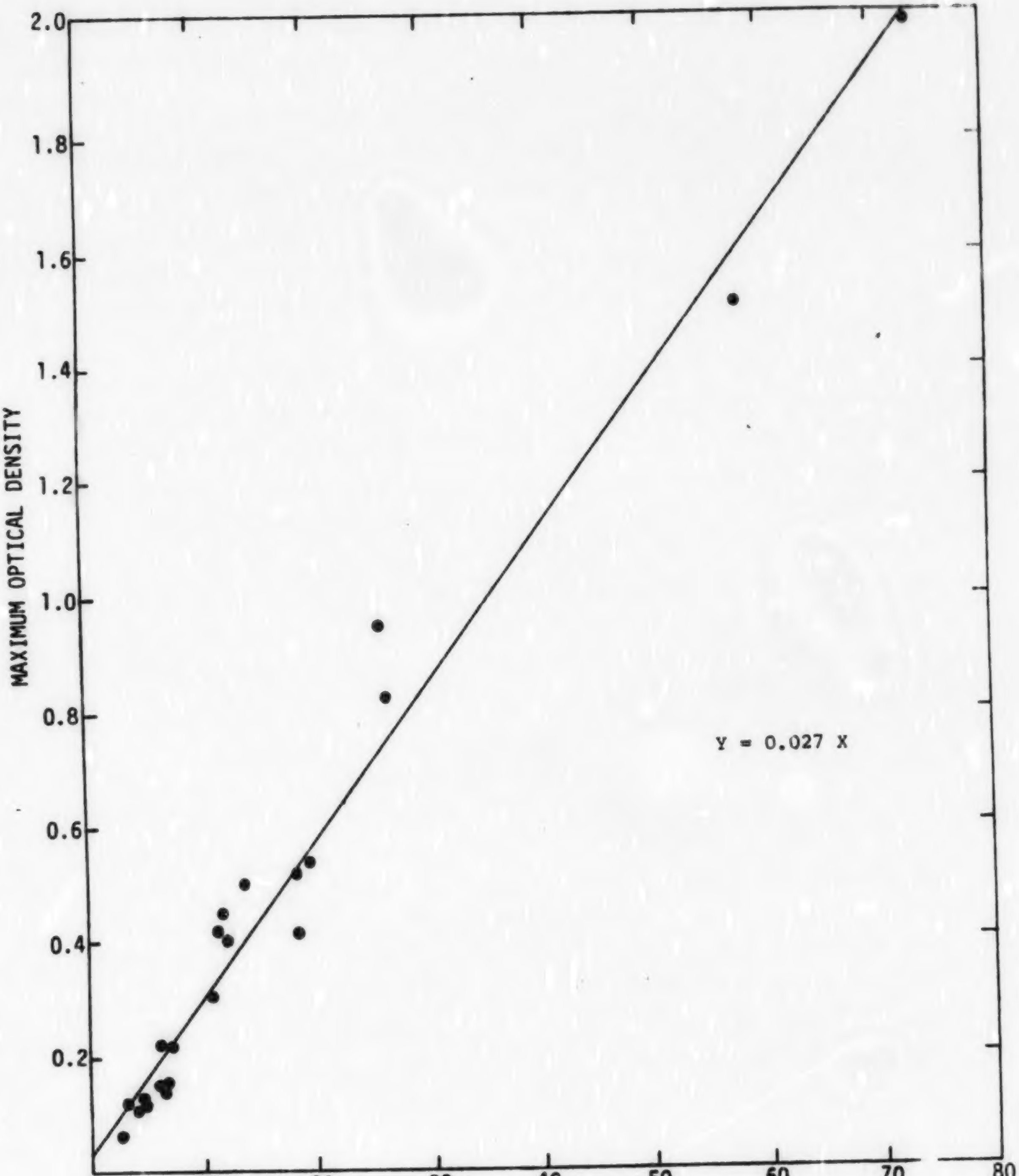

Figure 10. Relationship of peak optical density reading to optical density-seconds value calculated for coke push.

was considered to indicate reasonably well the overall greenness of a push. Since duration of the pushes varied somewhat, a time-weighted product of the duration, in seconds, and the sum of the degree-of-greenness ratings was selected as the parameter that would best characterize each push in terms of plume appearance and the emissions generated.

This degree-of-greenness index was used in several ways to analyze the impact of various process parameters on coke-side emissions. For example, the measured particulate mass emission rates, in pounds of filterable particulate per ton of feed, were plotted as a function of average degree-of-greenness rating for pushes observed during each of the four pushing-cycle particulate tests, as shown in Figure 11.[a] Although the correlation was good, showing that the greenness of the coke was a substantial factor in producing high emissions, the fact that Tests No. 1, 2, and 3 yielded nearly identical average degree-of-greenness ratings limited the usefulness of the correlation analysis.

A possible alternative technique for rating the greenness of the pushes would be to read and note only the highest intensity level occurring during any part of the push, without regard to the duration of the push. An expanded rating scale of 1 to 8, in place of the 1 to 4 scale, would better characterize the range of smoke intensities typically encountered at a coke plant. For evaluation of this alternative technique, the three-digit ratings recorded during the EPA study were converted to a single rating index by

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[a] This figure and a detailed discussion of the degree-of-greenness observations appear in the EPA contractor report referenced earlier.

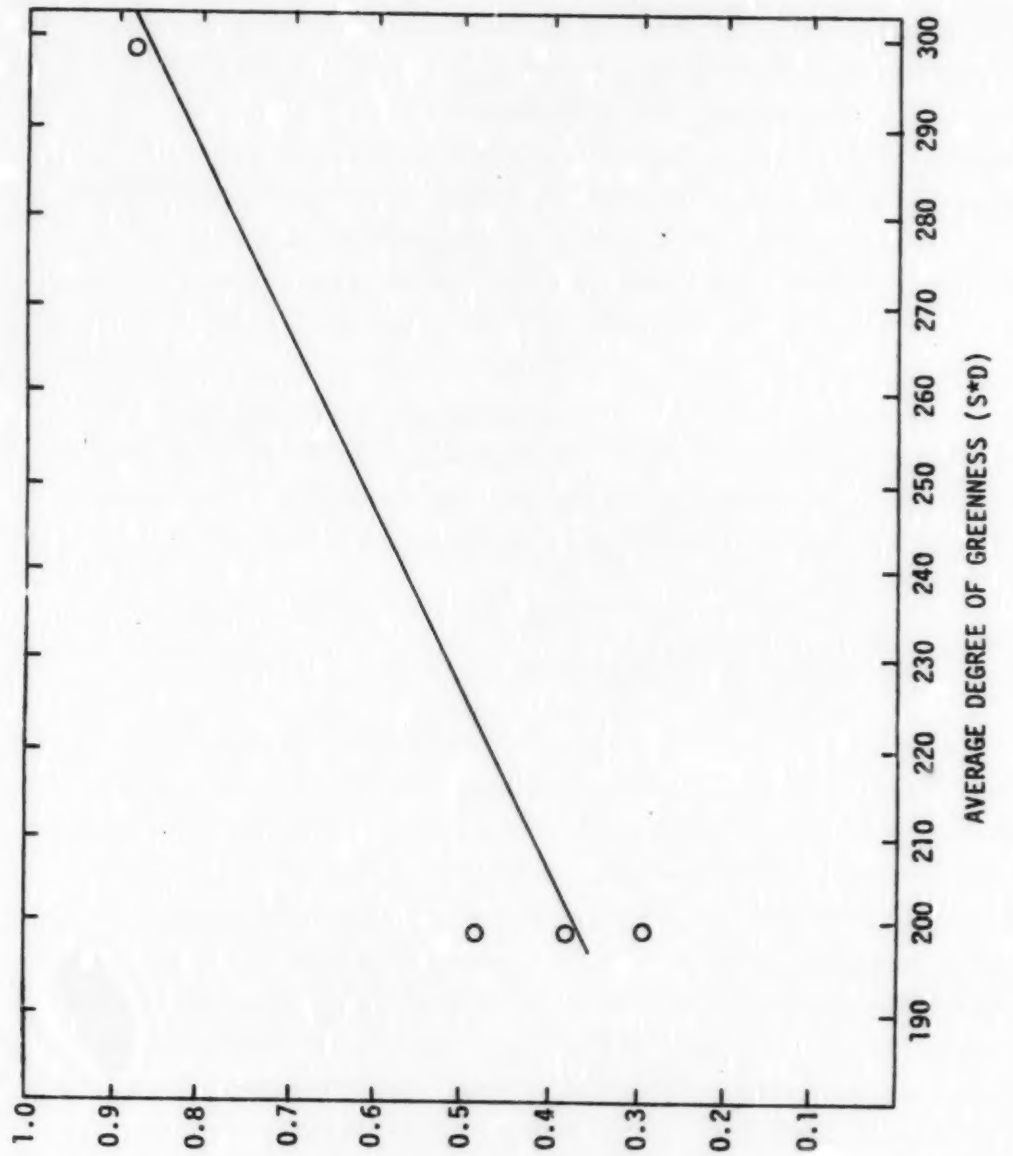

Figure 11. Degree of greenness versus filterable particulate emissions.

selecting only the highest rating reported; the results, plotted in the same format as in Figure 11, are shown in Figure 12.

The relationship in Figure 12 shows a much more consistent agreement between the degree-of-greenness and emission rates. Furthermore, if the mass emission rate data were expressed in pounds per hour, rather than as emission factors, pounds per ton of coal charged, the agreement would have been even closer. Further refinements of the subjective rating technique could make it more sensitive to emission variations, perhaps by giving some additional weight to the reading when an especially dense plume persists for more than half of the push period. Regardless of the technique used to evaluate greenness of a push, the data obtained during this study show that the degree-of-greenness rating is a useful tool in assessing coke-side emission potential at a coke plant.

IMPACT OF COKE PLANT OPERATING PRACTICES ON COKE-SIDE EMISSIONS

It is widely accepted that good coke-oven operating practices can achieve considerable reductions in coke-side emissions. Leakage from oven doors can be minimized by proper maintenance of the doors and door jambs and by careful luting of the door promptly after the coke push, at luted-door plants. Application of sufficient heat to the coal over a sufficient period will reduce the production of green coke, which is responsible for the release of copious quantities of smoke when it is pushed from the oven.

The visual appearance of coke-side emissions at the GLC plant is better than that of emissions at plants where good operating practices are not stressed. The transmissometer

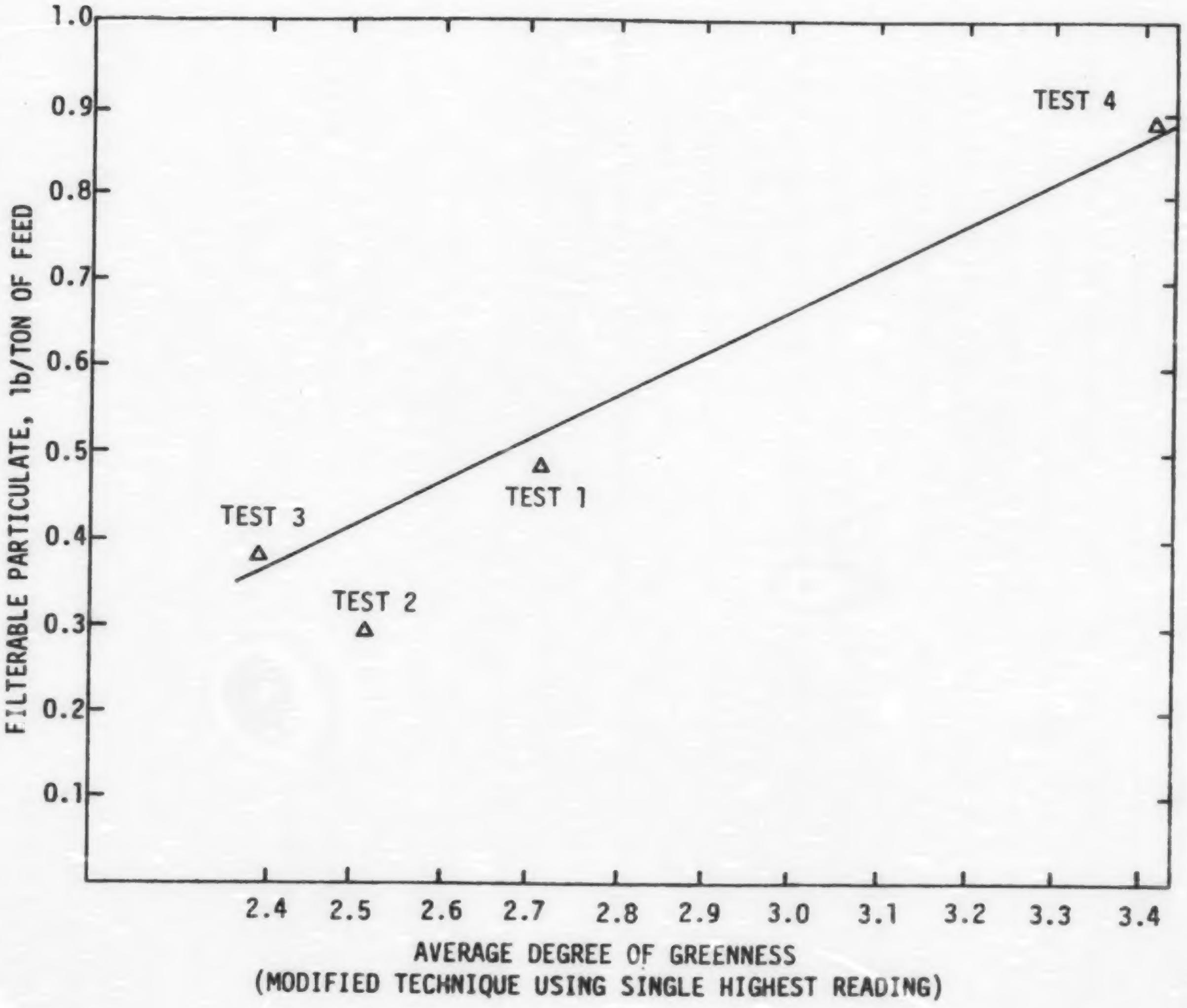

Figure 12. Degree of greenness versus filterable particulate emissions.

measurements and other data collected at the GLC plant indicate that most of the coke pushes during the 1-week emission testing period generated relatively small quantities of smoke. Although some leakage from doors was observed nearly all of the time, the number of doors leaking on the coke-side usually did not exceed 10 percent of the total number of ovens. Moreover, the smoke leaked generally was wispy and light in color. Overall, operations at the GLC plant reflected the intent to avoid unnecessary coke-side emissions wherever possible and practical. Local APC agency personnel assisting EPA in the study confirmed this observation and indicated that the visual appearance of the coke-push plumes during the testing period were representative of normal operations at this plant. The coke-side emission rates determined for the GLC plant are, therefore, judged to be indicative of emissions from a reasonably well-operated plant. If operation and maintenance were allowed to deteriorate appreciably, the magnitude of emissions would be expected to increase significantly.

The transmissometer measurements provide some insight into the potential impact of poor operating practices on coke-side emission rates. The following discussion explores the possible ranges of particulate emissions that could be contributed by various operational factors.

At the GLC plant, emissions from door leaks, evaluated visually, seem inconsequential when compared with the more spectacular short-term bursts occurring during the coke push. In contrast however, the transmissometer measurements and the emission test data both show that door leaks account for as much as half of the total coke-side emissions on a long-term basis, largely because of the continuous, persistent nature of the leaks. Any increase in either the number of leaking doors or the intensity of the leakage will produce a sizable impact on daily emissions rates. The upper curve in Figure 13 is a transmissometer chart tracing of background smoke densities recorded during a period when one or more oven doors were leaking more heavily than usual. The fluctuating baseline increases 2 to 3 times over the normal background level of approximately 0.006 optical density. Conceivably, if several oven doors consistently leaked heavily for periods of 1 hour or more, the average background smoke levels might increase 2-to-3-fold, causing a 30 to 50 percent increase in total daily coke-side emissions.

Figure 13 depicts other push operations that can also contribute measurably to coke-side particulate loadings. The middle curve shows a momentary increase in background smoke levels during cleaning of a door jamb. Also, the hot coke debris dropping from the coke guide on to the bench can add appreciably to background smoke density until the smoldering material is cleared from the bench. Perhaps the single, most significant nonpush emission source other than door leakage observed at the GLC plant was the occasional practice of removing the oven doors 5 to 10 minutes before the start of the push. The lower curve in Figure 13 shows a substantial increase in baseline emissions when the door was lifted off an oven that presumably contained a green coke end. These examples of operational factors causing higher-than-normal background emissions illustrate that well-coordinated and prompt performance of work assignments on the coke-side bench can help reduce nonpush emissions.

Emissions from pushing of the coke are highly visible and are the largest single source of coke-side emissions.

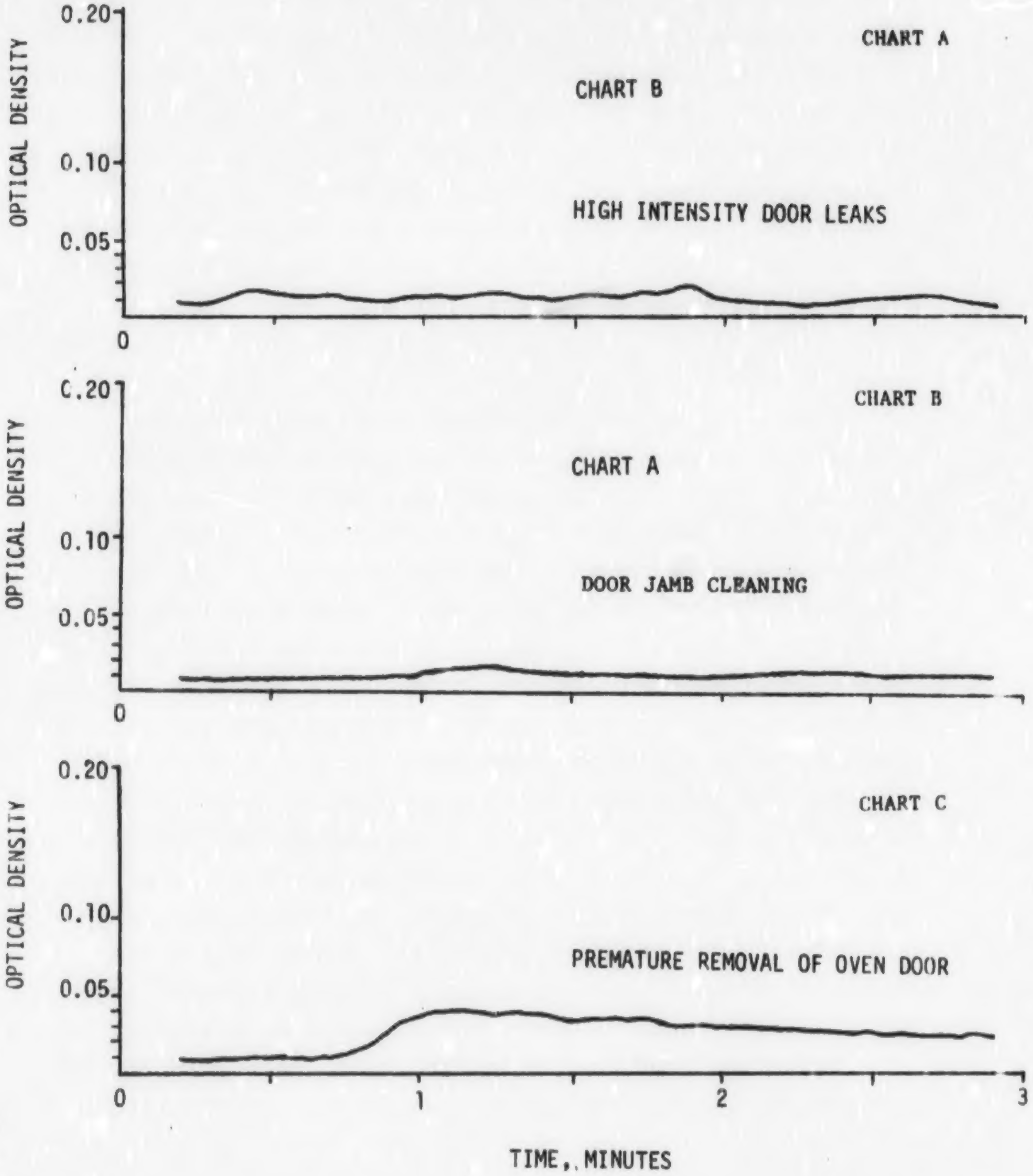

Figure 13. Examples of coke-side operations contributing to the nonpush background smoke density level.

This report has shown that the pushing of green coke exerts an overwhelming impact on emissions. The transmissometer tracing of one push, Oven No. 53 (in Figure 7) illustrates the maximum range of push emissions. Although not typical of normal plant operations, the emissions from this push may typify worst-case emissions, particularly, if deterioration of the oven heating systems and/or short-cycle coke production create a pattern of extremely dirty pushes.

If emissions from all five of the pushes during Test No. 4 had been of the same magnitude as those in the worst case, the average optical density for the emission test period would have been 0.057, which is approximately equivalent to an average grain loading of 0.062 grain/acf. Further calculation would give an emission rate of about 70 pounds per hour, or roughly 5 times the emission rate of 13.7 pounds per hour reported for Test No. 2.

Although the emission projections cited here are based on only a few observations and measurements, the estimates illustrate the potential impact of various operational factors on coke-side emissions. The coke-side emission factors developed for the GLC plant could be considered conservative, since smoke and dust emissions under less favorable operations and practices could easily range as high as 5 to 6 times the emission rates determined during the EPA study.

ACKNOWLEDGMENT

The authors acknowledge the assistance and guidance of Mr. W. D. Conner of the Environmental Science and Research Laboratory, EPA, NERC/RPT in the loan and calibration of the

transmissometer system and in formulation of convenient equations for expressing optical density in terms of particulate-mass concentration.

APPENDIX A

Transmissometer Calibration Curve	Figure A-1
Transmissometer Data Reduction Technique	Figure A-2
Ranking of Coke Pushes According to Peak Optical Density and Optical Density - Second Values	Tables A-1, A-2
Tabulation of Optical Density Data Derived for Push Cycle Emission Tests	Tables A-3 thru A-7

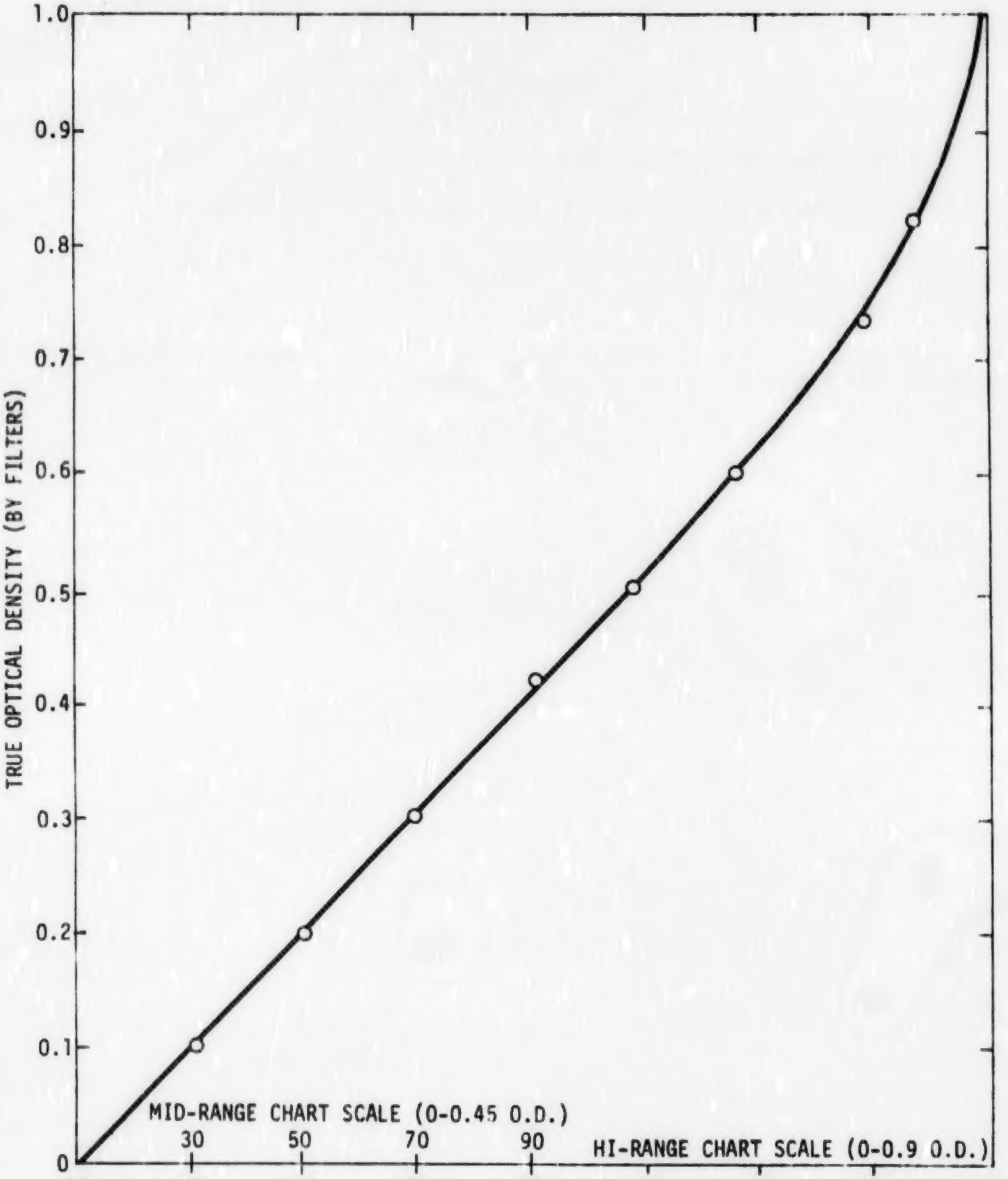

Figure A-1. Calibration curve for RM-4 LS transmissometer system used at GLC plant.

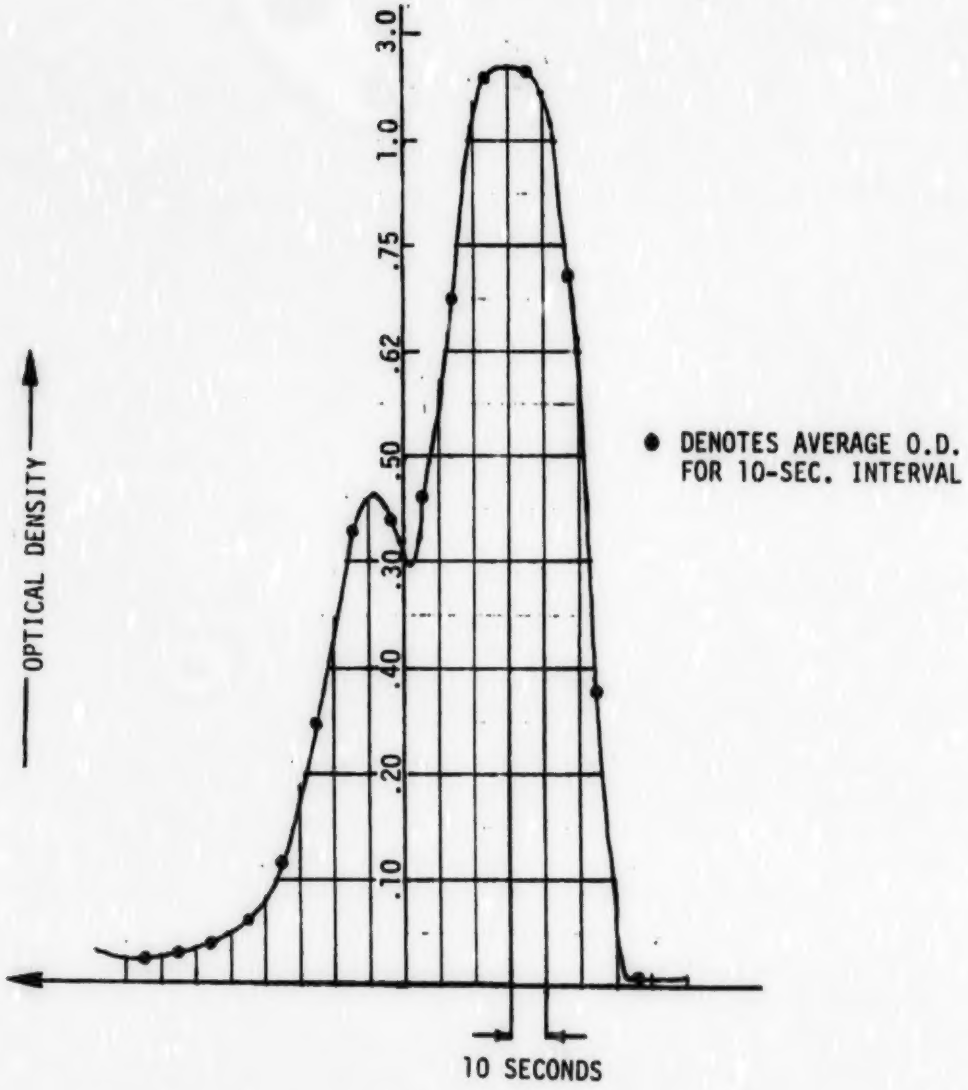

Figure A-2. Graphical method of estimating push peak area (optical density-seconds).

TABULATION AND RANKING OF PUSH EVENTS IN TERMS OF PEAK OPTICAL DENSITY AND OPTICAL DENSITY-TIME VALUE

TABLE A-1. PEAK OPTICAL DENSITY

RANK	PUSH NO.	DATE	PUSH RATING	OD PEAK VALUE
1	53	24th	3-4-4	2.000
2	27	23	3-4-2	1.500
3	12	21	4-4-4	1.250
4	7	23	2-1-4	.950
5	43	24	4-2-1	.820
6	17	21	3-3-2	.750
7	32	21	4-4-2	.750
8	12	22	4-4-4	.750
9	7	21	2-3-2	.680
10	25	22	3-3-2	.680
11	32	22	4-3-2	.680
12	17	22	4-3-2	.540
13	51	24	N/A	.520
14	25	23	3-2-2	.510
15	7	22	2-3-2	.500
16	37	23	2-2-1	.450
17	43	23	4-3-2	.450
18	47	23	4-2-1	.420
19	5	23	2-2-2	.420
20	13	24	4-3-2	.410
21	17	23	3-4-2	.300
22	47	21	3-1-1	.220
23	47	22	2-1-1	.220
24	41	24	N/A	.220
25	22	21	3-3-1	.200
26	45	22	2-1-2	.190
27	27	22	2-2-1	.167
28	13	23	2-1-1	.160
29	45	23	2-1-1	.160
30	5	22	1-3-1	.150
31	33	24	2-1-2	.150
32	22	22	2-1-1	.150
33	53	23	2-1-1	.134
34	55	21	2-1-1	.125
35	27	21	3-2-2	.120
36	15	23	2-1-1	.115
37	23	24	3-1-2	.108
38	37	21	2-1-2	.105
39	23	23	2-2-1	.105
40	37	22	1-1-1	.100
41	33	23	3-2-1	.100
42	55	23	1-2-1	.100
43	34	22	2-1-1	.095
44	42	21	4-3-2	.090
45	52	21	1-1-1	.090
46	15	22	2-2-2	.080
47	35	23	2-1-2	.075
48	2	21	2-2-1	.070
49	2	22	2-2-1	.060
50	14	22	2-2-1	.055

TABLE A-2. OPTICAL DENSITY-SECONDS VALUES

RANK	PUSH NO.	DATE	PUSH RATING	OD-SEC VALUE
1	53	24th	3-4-4	73.30
2	27	23	3-4-2	57.70
3	12	21	4-4-4	42.00
4	43	24	4-2-1	26.15
5	7	23	2-1-4	25.95
6	17	21	3-3-2	25.00
7	32	21	4-4-2	25.00
8	12	22	4-4-4	25.00
9	25	22	3-3-2	23.00
10	7	21	2-3-2	23.00
11	32	22	4-3-2	23.00
12	17	22	4-3-2	19.60
13	33	24	4-3-2	18.48
14	51	24	N/A	18.31
15	25	23	3-2-2	17.50
16	43	23	4-3-2	15.00
17	5	23	2-2-2	14.00
18	7	22	2-3-2	13.72
19	37	23	2-2-1	11.80
20	47	23	4-2-1	11.14
21	17	23	3-4-2	10.97
22	47	22	2-1-1	7.50
23	22	21	3-3-1	7.00
24	47	21	3-1-1	7.31
25	45	22	2-1-2	6.50
26	33	24	2-1-2	6.34
27	41	24	N/A	6.32
28	27	22	2-2-1	6.14
29	13	23	2-1-1	5.50
30	45	23	2-1-1	5.50
31	5	22	1-3-1	5.00
32	53	23	2-1-1	5.00
33	22	22	2-1-1	5.00
34	23	24	3-1-2	4.84
35	27	21	3-2-2	4.52
36	55	21	2-1-1	4.50
37	23	23	2-2-1	4.00
38	15	23	2-1-1	4.00
39	37	21	2-1-2	3.84
40	42	21	4-3-2	3.50
41	52	21	1-1-1	3.50
42	37	22	1-1-1	3.50
43	33	23	3-2-1	3.50
44	55	23	1-2-1	3.50
45	34	22	2-1-1	3.50
46	14	22	2-2-1	2.69
47	2	22	2-2-1	2.50
48	35	23	2-1-2	2.50
49	2	21	2-2-1	2.50
50	15	22	2-2-1	2.00

TABLE A-3. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST NO. 1, APRIL 21-22, 1975.

STRIP CHART NO.		MODE OF OPERATION	DATE/TIME		TABULATION CODE(1) TEST/MODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (SEC.)	PUSH RATING
6		START TEST @ 1035	21st							
	3	PUSH NO. 7		103500	0	1	2300	680	110	2-3-2
	4	NON PUSH PERIOD		3650		2	936	030	1090	
	5	PUSH NO. 17		5500	0	1	2500	750	110	3-3-2
	6	NON PUSH PERIOD		5650		2	340	004	850	
		STOP TEST @ 1111								
		START TEST @ 1225								
7	1	PUSH NO. 27		122500	1	1	452	120	90	3-2-2
	2	NON PUSH PERIOD		2630		2	643	005	1290	
	3	PUSH NO. 37		4800	1	1	384	105	90	2-1-2
	4	NON PUSH PERIOD		4930		2	345	005	690	
		STOP TEST @ 1301								
		STARTTEST @ 1304								
	5	PUSH NO. 47		130400	1	1	731	220	100	3-1-1
	6	NON PUSH PERIOD		0540		2	536	004	1340	
		STOP TEST @ 1328								
		START TEST @ 1629								
	7	PUSH NO. 2		162900	0	1	250	070	110	2-2-1
	8	NON PUSH PERIOD		3050		2	148	004	370	
	9	PUSH NO. 12		3700	0	1	4200	1250	120	4-4-4
	10	NON PUSH PERIOD		3900		2	216	006	360	
	11	PUSH NO. 22		4500	0	1	700	200	110	3-3-1
	12	NON PUSH PERIOD		4650		2	366	006	610	
	13	PUSH NO. 32		5700	0	1	2500	750	120	4-4-2
	14	NON PUSH PERIOD		5900		2	384	008	480	
	15	PUSH NO. 42		170700	1	1	350	090	110	4-3-2
	16	NON PUSH PERIOD		850		2	196	004	490	
		STOP TEST @ 1717								
		START TEST @ 1900								
	17	NON PUSH PERIOD		1900		2	168	004	420	
	18	PUSH NO. 52		2600	1	1	350	090	110	1-1-1
	19	NON PUSH PERIOD		2750		2	652	004	1630	
		STOP TEST @ 1755								
10		START TEST @ 0949	22nd							
	4	PUSH NO. 5		094900	0	1	500	150	110	1-3-1
	5	NON PUSH PERIOD		5050		2	629	015	970	
	6	PUSH NO. 15		100700	0	1	200	080	110	2-2-1
	7	NON PUSH PERIOD		0850		2	1940	050	970	
		STOP TEST @ 1025								
		START TEST @ 1029								
	8	PUSH NO. 25		2900	0	1	2300	680	110	3-3-2
	9	NON PUSH PERIOD		3050		2	269	035	130	
		STOP TEST @ 1033								
		TEST NUMBER ONE CONTINUED IN TABLE 3-A								

TABLE A-3A. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST NO. 1, APRIL 21-22, 1975.

STRIP CHART NO		MODE OF OPERATION	DATE/TIME	TABULATION CODE(1) TEST/MODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (Sec.)	PUSH RATING
10		START TEST @ 1049	22nd						
	10	NON PUSH PERIOD	104900		2	24	004	60	
		STOP TEST @ 1050							
		START TEST @ 1055							
	11	PUSH NO. 45	5500	0	1	650	190	110	2-1-2
	12	NON PUSH PERIOD	5650		2	1050	040	1750	
	13	PUSH NO. 55	112600	0	1	450	125	110	2-2-1
	14	NON PUSH PERIOD	2750		2	1025	005	2050	
		END TEST @ 1202							

TABLE A-4. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST NO. 2, APRIL 22, 1975.

STRIP CHART NO.		MODE OF OPERATION	DATE/TIME	TABULATION CODE TEST/MODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (Sec.)	PUSH RATING
11		START TEST @ 1410	22nd						
	1	PUSH NO. 7	141000	1	1	1372	500	100	2-3-2
	2	NON PUSH PERIOD	1140		2	420	005	860	
	3	PUSH NO. 17	2600	1	1	1960	540	105	4-3-2
	4	NON PUSH PERIOD	2745		2	549	012	915	
	5	PUSH NO. 27	4300	1	1	614	167	110	2-2-1
	6	NON PUSH PERIOD	4450		2	312	004	790	
		STOP TEST @ 1458							
		START TEST @ 1500							
	7	NON PUSH PERIOD	150000		2	480	004	1200	
		STOP TEST @ 1520							
		START TEST @ 1522							
	8	PUSH NO. 37	2200	0	1	350	100	110	1-1-1
	9	NON PUSH PERIOD	2350		2	584	020	730	
	10	PUSH NO. 47	3600	0	1	750	220	110	2-1-1
	11	NON PUSH PERIOD	3750		2	292	020	730	
		STOP TEST @ 1550							
		START TEST @ 1554							
	12	NON PUSH PERIOD	5400		2	480	004	1200	
	13	PUSH NO. 14	161400	1	1	269	055	90	2-2-1
	14	NON PUSH PERIOD	1530		2	204	004	510	
	15	PUSH NO. 34	2400	0	1	350	095	110	2-1-1
	16	NON PUSH PERIOD	2550		2	388	004	970	
		STOP TEST @ 1642							
		START TEST @ 1644							
	17	NON PUSH PERIOD	4400		2	288	004	720	
		STOP TEST @ 1656							
12		START TEST @ 1812							
	1	PUSH NO. 2	181200	0	1	250	060	110	2-2-1
	2	NON PUSH PERIOD	1350		2	185	005	370	
	3	PUSH NO. 12	2200	0	1	2500	750	110	4-4-4
	4	NON PUSH PERIOD	2350		2	430	025	430	
	5	PUSH NO. 22	3100	0	1	500	150	110	2-1-1
	6	NON PUSH PERIOD	3250		2	268	015	670	
	7	PUSH NO. 32	4400	0	1	2300	680	110	4-3-2
	8	NON PUSH PERIOD	4550		2	225	012	250	
		END TEST @ 1848							

TABLE A-5. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST NO. 3, APRIL 23, 1975.

STRIP CHART NO.	MODE OF OPERATION	DATE/TIME	TABULATION CODE TEST/MODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (Sec.)	PUSH RATING
13	START TEST @ 0845	23th						
4	NON PUSH PERIOD	084500		2	36	006	60	
5	PUSH NO. 23	4600	0	1	400	105	110	2-2-1
6	UNKNOWN MODE	4750		2	2394	018	1320	
7	PUSH NO. 33	091000	0	1	350	100	110	3-2-1
8	UNKNOWN MODE	1150		2	730	010	730	
9	PUSH NO. 43	2400	0	1	1500	450	110	4-3-2
10	NON PUSH PERIOD	2550		2	245	005	490	
	STOP TEST @ 0934							
	START TEST @ 0936							
12	NON PUSH PERIOD	3600		2	600	005	1200	
	STOP TEST @ 0956							
	START TEST @ 1008							
14	PUSH NO. 53	100800	0	1	500	134	110	2-1-1
15	NON PUSH PERIOD	0950		2	546	006	910	
	STOP TEST @ 1025							
	START TEST @ 1102							
15A	NON PUSH PERIOD	110200		2	72	004	180	
	STOP TEST @ 1105							
	START TEST @ 1307							
16	PUSH NO. 5	130700	0	1	1400	420	110	2-2-2
17	NON PUSH PERIOD	0850		2	148	004	370	
	STOP TEST @ 1315							
	START TEST @ 1317							
19	NON PUSH PERIOD	1700		2	144	004	360	
20	PUSH NO. 15	2300	0	1	400	115	110	2-1-1
21	NON PUSH PERIOD	2450		2	316	004	790	
22	PUSH NO. 25	3800	0	1	1750	510	110	3-2-2
23	NON PUSH PERIOD	3950		2	412	004	1030	
24	PUSH NO. 35	5700	0	1	250	075	110	2-1-2
25	NON PUSH PERIOD	5850		2	220	004	550	
	STOP TEST @ 1408							
	START TEST @ 1410							
25A	NON PUSH PERIOD	141000		2	96	004	240	
26	PUSH NO. 45	1400	0	1	550	160	110	2-1-1
27	NON PUSH PERIOD	1550			492	004	1030	
28	PUSH NO. 55	3300	0	1	350	100	110	1-2-1
28	NON PUSH PERIOD	3450		2	578	004	1450	
	END TEST @ 1459							

TABLE A-6. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST NO. 4, APRIL 24, 1975.

STRIP CHART NO		MODE OF OPERATION	DATE/TIME	TABULATION CODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (Sec.)	PUSH RATING
				TEST	MODE				
16		START TEST @ 1043	24th						
	10	NON PUSH PERIOD	104300		3	212	025	155	
	11	PUSH NO. 13	4535	1	1	1848	410	115	4-3-2
	12	NON PUSH PERIOD	4725		3	393	048	150	
	13	NON PUSH PERIOD	5005		2	280	010	280	
17	1	NON PUSH PERIOD	5440		2	909	009	1010	
	2	PUSH NO. 23	111100	1	1	484	108	100	3-1-2
	3	NON PUSH PERIOD	1240		3	188	017	170	
		STOP TEST @ 1116							
		START TEST @ 1119							
	5	NON PUSH PERIOD	1900		2	670	010	670	
	6	PUSH NO. 33	3150	1	1	634	150	110	2-1-2
	7	NON PUSH PERIOD	3240		3	294	020	210	
	8	NON PUSH PERIOD	3620		2	288	006	480	
18	1	NON PUSH PERIOD	4410		2	270	006	450	
		STOP TEST @ 1151							
		START TEST @ 1155							
	3	NON PUSH PERIOD	5500		2	180	006	300	
		STOP TEST @ 1200							
		START TEST @ 1245							
	5	PUSH NO. 43	124500	1	1	2615	820	110	4-2-1
	6	NON PUSH PERIOD	4650		3	203	020	130	
	7	NON PUSH PERIOD	4900		2	886	038	840	
19	1	NON PUSH PERIOD	130300		2	336	008	420	
		STOP TEST @ 1310							
		START TEST @ 1314							
	3	PUSH NO. 53	1400	1	1	7330	2000	140	3-4-4
	4	NON PUSH PERIOD	1620		3	492	035	200	
	5	NON PUSH PERIOD	1940		2	624	010	1340	
	6	NON PUSH PERIOD	4200		2	72	006	120	
		END TEST @ 1344							

TABLE A-7. TABULATION OF OPTICAL DENSITY DATA REDUCED FROM TRANSMISSOMETER MEASUREMENTS MADE DURING THE GLC COKE PLANT TEST PERIOD, APRIL 23, 1975.

STRIP CHART NO.		MODE OF OPERATION	DATE/TIME	TABULATION CODE TEST/MODE		TOTAL OD VALUE	MAX. OD SCALE	DURATION (Sec.)	PUSH RATING
14	1	NON PUSH PERIOD	23th 164100		2	21	003	70	
	2	PUSH NO. 7	4210	1	1	2595	950	100	2-1-4
	3	NON PUSH PERIOD	4400		2	264	004	670	
	4	PUSH NO. 17	5510	1	1	1097	300	110	3-4-2
	5	NON PUSH PERIOD	5700		2	202	010	370	
	6	NON PUSH PERIOD	170310		2	324	022	240	
	7	PUSH NO. 27	0910	1	1	5770	1500	90	3-4-2
	8	NON PUSH PERIOD	1040		2	326	013	450	
	9	PUSH NO. 37	1610	1	1	1180	450	100	2-2-1
	10	NON PUSH PERIOD	1750		2	235	010	470	
	11	PUSH NO. 47	2530	1	1	1114	420	80	4-2-1
	12	NON PUSH PERIOD	3210		2	188	013	860	